PB82-142548

Background Research for Missouri Inspection/Maintenance Regulations

PEDCo-Environmental, Inc.
Kansas City, MO

Prepared for

Environmental Protection Agency
Kansas City, MO

Sep 81

U.S. Department of Commerce
National Technical Information Service
NTIS

TECHNICAL REPORT DATA

(Please read Instructions on the reverse before completing)

1. REPORT NO.
EPA 907/9-81-005

2.

3. RECIPIENT'S ACCESSION NO.
PB82 142548

4. TITLE AND SUBTITLE
Background Research for Missouri I/M Regulations

5. REPORT DATE
September 1981

6. PERFORMING ORGANIZATION CODE
364055

7. AUTHOR(S)

8. PERFORMING ORGANIZATION REPORT NO.
PN 3525-13

9. PERFORMING ORGANIZATION NAME AND ADDRESS
PEDCo Environmental, Inc.
2420 Pershing Road
Suite 300, Crown Center
Kansas City, Missouri 64108

10. PROGRAM ELEMENT NO.

11. CONTRACT/GRANT NO.
68-02-3512
Task Order No. 13

12. SPONSORING AGENCY NAME AND ADDRESS
U.S. Environmental Protection Agency
Region VII
324 East Eleventh Street
Kansas City, Missouri 64106

13. TYPE OF REPORT AND PERIOD COVERED
Final

14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

16. ABSTRACT

The 1977 Clean Air Act Amendments defined inspection and maintenance as a reasonable technique for the control of CO and O_3 and mandated its implementation in those areas where the states cannot demonstrate attainment of the standards by December 31, 1982. This document presents the results of the background research performed for the State of Missouri to assist in formulating their program and is a compilation of four separate reports: (1) Emission Analyzer Specifications; (2) Quality Assurance Procedures; (3) Inspection Station Requirements; and (4) Standardized Procedures for Emissions and Tampering Inspections. The basic procedure was to review the experience obtained in other I/M programs and to formulate a specific program for the State of Missouri based on their unique needs. In addition to summarizing the experience of others, the evaluation of the costs of the various aspects of the proposed program are included.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
I/M Inspection/Maintenance Missouri I/M	Emission analyzers Quality assurance Tampering inspections Inspection procedures Station requirements	

18. DISTRIBUTION STATEMENT
Release unlimited

19. SECURITY CLASS *(This Report)*
Unclassified

20. SECURITY CLASS *(This page)*
Unclassified

21. NO. OF PAGES

22. PRICE

EPA Form 2220-1 (9-73)

United States
Environmental Protection
Agency

Air, Noise and Radiation Branch
Region 7
324 East Eleventh St.
Kansas City, Mo. 64106

EPA 907/9-81-005
August, 1981

PB82-142548

Air

EPA

Background Reseach For Missouri I/M Regulations

PRODUCT OF:
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

BACKGROUND RESEARCH FOR MISSOURI INSPECTION/MAINTENANCE REGULATIONS

by

PEDCo Environmental, Inc.
2420 Pershing Road
Kansas City, Missouri 64108

Contract No. 68-02-3512
Task Order No. 13
PN 3525-13

Project Officer

Michael T. Marshall

U.S. ENVIRONMENTAL PROTECTION AGENCY
REGION VII
324 EAST ELEVENTH STREET
KANSAS CITY, MISSOURI 64106

September 1981

DISCLAIMER

This Final Report was furnished to the U.S. Environmental Protection Agency by PEDCo Environmental, Inc., Cincinnati, Ohio in fulfillment of Contract Number 68-02-3512, Assignment Number 13. The opinions, findings, and conclusions expressed are those of the authors and not necessarily those of the Environmental Protection Agency or of cooperating agencies. Mention of company or product name is not to be considered as an endorsement by the Environmental Protection Agency.

PREFACE

The Clean Air Act Amendments of 1977 defined inspection and maintenance (I/M) as a reasonable technique for the control of carbon monoxide and ozone and mandated its implementation in those areas where the states cannot demonstrate attainment of the air quality standards for these pollutants by December 31, 1982.

The State of Missouri is in the development phase for their I/M program and certain aspects of this proposed program needed to be evaluated prior to implementation. This report presents the results of the background research performed for the State of Missouri to assist in the development of their program. The basic procedure was to review the experience obtained in other I/M programs and to formulate a specific program for the State of Missouri based on their unique needs. This document contains four separate reports which summarize the results for the major research topics:

1. Emission Analyzer Specifications
2. Quality Assurance Procedures
3. Inspection Station Requirements
4. Standardized Procedures for Emissions and Tampering Inspections

The first three reports were prepared and distributed separately in final form in June 1981 and are reprinted here. The final form of the fourth report has been presented only in this document.

EMISSION ANALYZER SPECIFICATIONS

CONTENTS

Page

Figures iv
Tables v

1.0 Introduction 1
  1.1 Purpose 1
  1.2 Existing emission analyzer specifications 1
  1.3 Principles of emission analyzer operation 2
  1.4 Report organization 6
  1.5 Summary 6
  References 7

2.0 Accuracy of Readings 8
  2.1 Analyzer calibration accuracy 8
  2.2 Zero and span drift 10
  2.3 HC hangup 10
  2.4 Gas and electrical interferences 12
  2.5 Leaks 15
  2.6 Repeatability 15

3.0 Analyzer Features Affecting Measured Values 19
  3.1 Temperature and humidity operating range 19
  3.2 Warmup time and lockout 21
  3.3 Probe design 21
  3.4 Sample line design 23
  3.5 Water removal system 25
  3.6 Conversion factor 25
  3.7 Low flow indicator 29
  3.8 Meter design 29
  3.9 Instrument range 31
  3.10 Response time 34
  3.11 Internal or external gas for calibration 34
  References 38

4.0 Construction, Materials, and Dependability 39
  4.1 Materials and finish, vibration and shock protection 39
  4.2 Particulate filter 39
  4.3 Pump 42
  4.4 Dependability 42

5.0 Additional Analyzer Features for Decentralized Programs Recommended by EPA 45
  5.1 Technical overview 45
  5.2 Evaluation 47
  References 48

CONTENTS (continued)

		Page
6.0	Analyzer Availability	49
	6.1 Range of analyzers available	49
	6.2 Selecting the analyzer	49
	6.3 Certification of units	52
7.0	Evaluation of Analyzer Specifications	53
	7.1 Technical overview	53
	7.2 Operator error	57
	7.3 Change in I/M program costs related to emission analyzer selected	59
	7.4 Recommended analyzer specifications	60

Appendices

A.	Analyzer Specification Evaluation	62
B.	Change in I/M Program Costs Related to Emission Analyzer Selected	75

FIGURES

Number		Page
1-1	Schematic Diagram of Typical Emission Analyzer	4

TABLES

Number		Page
1-1	Emission Analyzer Specifications Adopted by Other States	3
2-1	Comparison of Specifications for Analyzer Accuracy	9
2-2	Comparison of Specifications for Drift	11
2-3	Comparison of Specifications for HC Hangup	13
2-4	Comparison of Specifications for Gas and Electrical Interference	14
2-5	Comparison of Specifications for Leaks	16
2-6	Comparison of Specifications for Repeatability	18
3-1	Comparison of Specifications for Temperature and Humidity	20
3-2	Comparison of Specifications for Warmup Time and Lockout	22
3-3	Comparison of Specifications for Probe Design	24
3-4	Comparison of Specifications for Sample Line Design	26
3-5	Comparison of Specifications for the Water Removal System	27
3-6	Comparison of Specifications for the Propane to Hexane Conversion Factor	28
3-7	Comparison of Specifications for Low Flow Indicator	30
3-8	Comparison of Specifications for Meter Design	32

TABLES (continued)

Number		Page
3-9	Comparison of Values for Instrument Range	33
3-10	Comparison of Values for Response Time	35
3-11	Comparison of Specifications for Internal/ External Gas Systems	36
4-1	Comparison of Specifications for Materials, Finish, Vibration, and Shock Protection	40
4-2	Comparison of Specifications for Particulate Filters	41
4-3	Comparison of Specifications for Pumps	43
6-1	Analyzer Availability	50
7-1	Cumulative Measurement Error	55
7-2	Summary of Results	56
7-3	Effect of Measurement Error on Program Stringency	58

SECTION 1.0

INTRODUCTION

1.1 PURPOSE

The purpose of this report is to provide technical information to the State of Missouri on emission analyzers potentially available for use in a mandatory decentralized inspection/maintenance program. The report will serve as the technical basis for the state in adopting regulations for emission analyzer specifications.

1.2 EXISTING EMISSION ANALYZER SPECIFICATIONS

1.2.1 Nationally Recognized Analyzer Standards

Automobile exhaust analyzers have been commercially available for several years prior to the concept of an auto inspection/maintenance program and have been used at auto repair facilities for tune-up and diagnostic work. Using the emission analyzer for inspection program places a new burden of accuracy on the instrument.

Several attempts to improve the emission analyzer have been made by establishing minimum specifications. There are four such sets of minimum specifications that have been circulated nationally. In 1974, the California Bureau of Automotive Repair (BAR) published minimum instrument specifications for garages participating in its Blue Shield program. These are generally known as BAR 74 specifications (California Bureau of Automotive Repair 1974). In 1979, BAR upgraded these specifications, and they are now known as the BAR 80 specifications (California Bureau of Automotive Repair 1979). The Equipment and Tool Institute (ETI) has also developed a set of specifications (Equipment and Tool Institute 1979) that contain many common elements with the BAR 74 specifications. The most restrictive set of specifications are recommendations (not requirements) developed by the Environmental Protection Agency (U.S. EPA 1980). One subset applies to manual operation analyzers recommended for centralized programs, while the other subset references specifications for computerized units recommended for decentralized programs. The EPA specifications are under minor revision. All states with an existing or planned

I/M program use one of these basic four sets of specifications or a slight variation of them.

1.2.2 Section 207(b) Requirements

Section 207 of the Clean Air Act also contains emission analyzer specifications. Section 207(b) is a consumer protection measure that requires vehicle manufacturers to warrant that a 1981 or later vehicle will conform to emission standards throughout its useful life providing that the vehicle is properly maintained and operated. If the vehicle fails an "approved short test", the manufacturer must repair the vehicle free of charge to the consumer. Subsequent EPA promulgations have defined useful life of a vehicle as five years and have defined the vehicle parts that vehicle manufacturers must warrant. For 5 years, all emission control devices must be warranted including the catalyst, air pump, and electronic controls. For the first 2 years/24,000 miles, parts of the ignition system (spark plugs, ignition wires, and similar components) are also covered.

In order for a consumer to take advantage of the vehicle warranty, the vehicle must be tested using an "approved short test". An approved short test is an idle test with an emissions analyzer meeting specifications listed in the regulations. Missouri's proposed idle test would meet the 207(b) requirements. However, for Missouri consumers to take advantage of 207(b) warranty benefits, the emission analyzer specifications for the Missouri I/M program must be as stringent as the 207(b) emission analyzer specifications. Relating the 207(b) emission analyzer specifications to the four national sets of analyzer specifications described previously, ETI and BAR 74 standards are not as stringent as the 207(b) requirements whereas BAR 80 and EPA specifications are as stringent.

1.2.3 Specifications Adopted for Other State I/M Programs

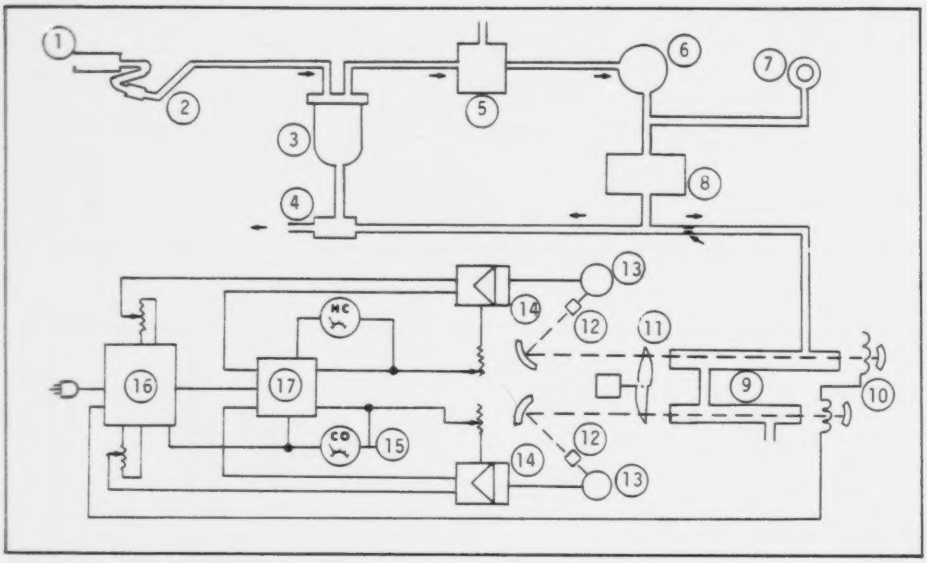
Table 1-1 shows which states are committed to the respective sets of analyzer specifications. Only 21 states have decided which set of specifications to use. Eleven states have chosen the BAR 80 specifications. Indiana has chosen EPA specifications while two other states have specified Section 207(b) specifications. The remaining states have specified BAR 74 or ETI specifications.

1.3 PRINCIPLES OF EMISSION ANALYZER OPERATION

The principles of emission analyzer operation are reviewed in the following paragraphs in order to aid in understanding the operation of emission analyzers. A schematic diagram of a typical emission analyzer and a basic operational description is included in Figure 1-1.

TABLE 1-1. EMISSION ANALYZER SPECIFICATIONS ADOPTED BY OTHER STATES

Region	State	ETI	BAR 74	BAR 80	EPA	Other	Decision not yet made by state
I	Conn.			•			
	Mass.						•
	R.I.	•					
II	N.J.		•				
	N.Y.			•			
III	D.C.						•
	Del.					207(b)	
	Md.	certified repair stations		centralized contractor, fleet station			
	Pa.			•			
	Va.						•
IV	Ga.						•
	Ky.						•
	N.C.						•
	Tenn.			•			
V	Ill.						•
	Ind.				•		
	Mich.		• with modifications				
	Ohio						•
	Wis.			•			
VI	N. Mex.	Garages		Fleets			
	Tex.						•
VII	Kans.			•			
VIII	Colo.		• with grand father clause	• with modifications			
	Utah		•				
IX	Ariz.			•			
	Nev.	•					
X	Oreg.		•				
	Wash.					207(b)	
	Calif.			•			



Exhaust gas is collected at the tailpipe (1) and drawn through the pick-up and hose (2). Condensation flows into a water trap (3) and is removed by an aspirator (4). The gas continues through the selector valve (5) and filter (6) which removes solids. The vacuum switch (7) signals gas line restrictions. Gas then flows into the pump (8) and is forced through the HC and CO sampling tubes (9). The restrictor allows some gas flow through the aspirator venturi.

Infrared energy, generated by a hot filament (10), is projected through the sample tubes. The infrared beam is chopped by a synchronized disc (11), focused on a filter (12) and converted to an electrical signal by the detector (13). The signal is coupled to an amplifier (14) which drives the meter (15). Reference (16) is the d.c. power supply for the emissions analyzer package.

The p.c. board (17) provides calibration adjustment of HC/CO span and high meter ranges.

Figure 1-1. Schematic Diagram of Typical Emission Analyzer.

The analyzer samples exhaust gases and provides meter readings for percent of carbon monoxide (CO) and parts per million hydrocarbon (ppm HC) emissions. Quantitative analysis of CO and HC is determined by the amount of infrared energy absorbed by the gas sample. CO absorbs energy of 4.65 micron wavelength and HC absorbs energy of 3.42 micron wavelength. Since the analysis principle is the same for both gases, only CO detection will be described.

An infrared beam is directed through a sample tube and focused on a detector. In front of the detector is an optic filter that permits 4.65 micron wavelength to pass. CO will absorb energy of 4.65 micron wavelength. Other gases in the sample tube absorb energy of different wavelengths; therefore, the optic filter must pass only the wavelength in which CO absorbs infrared energy. The detector senses the infrared energy as heat and transforms it into electrical voltage.

With no CO in the sample tube, a voltage of about 60 microvolts is developed by the detector. This signal becomes weaker as the amount of CO increases. Amplifying such a small d.c. voltage is very difficult due to drift; so the signal is converted to a.c. by chopping the infrared beam with a rotating disc before it reaches the detector. Holes within this disc and the speed it rotates allow 10 pulses of infrared energy to strike the detector each second. The detector output is 10 hertz, the amplitude changing inversely with the amount of infrared energy passing through the sample tube.

The detector output is coupled to the preamp stage of the amplifier p.c. board. The preamp is a high gain, low noise amplifier. The preamp output is coupled to the electronic filter stage which is sharply tuned to 10 Hz. In this stage, all unwanted noise or random signals are blocked and do not appear in the output. A test point is provided on the amplifier p.c. board for measuring the a.c. output from this stage. It will be approximately 3.5 volts a.c. with no CO in the sample tube.

The a.c. output from the electronic filter stage is rectified and filtered and coupled to the comparer stage. At this point an equal d.c. voltage of opposite polarity is injected by the Air Adjust pot. This cancels the signal voltage and gives a zero meter reading. If CO is introduced into the sample tube, the signal voltage is reduced, and the difference compared and amplified by the comparer stage. The output from this stage is applied to the meter via the Span Adjust potentiometer, and provides an accurate reading in percent of CO present (BAR Automotive Service Equipment Company 1980).

1.4 REPORT ORGANIZATION

The emission analyzer specifications deal with items of analyzer construction and operation that determine the ability of the analyzer to obtain valid emission measurements. These elements have been grouped into four categories and appear as Sections 2 through 5. Section 6 contains a description of all analyzers now available, their cost, and which specifications they meet. Findings are presented in Section 7.

1.5 SUMMARY

Based on the findings of this report, the BAR 80 specifications are recommended because of availability of the analyzers, compatibility with Section 207(b) requirements, overall accuracy with respect to meeting the I/M program air quality goals, and protection against operator error.

REFERENCES

Bear Automotive Service Equipment Company. 1980. Model 42-080 Fuel Economy Analyzer Operating Instructions. Milwaukee, Wisconsin.

California Bureau of Automotive Repair. 1974. Performance Criteria, Design Guidelines, and Accreditation Procedures for Hydrocarbon and Carbon Monoxide Analyzers Required in California Official Motor Vehicle Pollution Control Systems. Sacramento, California.

California Bureau of Automotive Repair. 1979. Exhaust Gas Analyzer Specifications. Sacramento, California.

Equipment and Tool Institute. 1979. ETI Model Specifications for Garage Type NDIR HC CO Measurement Instruments for Use in the Garage Phase of State I&M Programs.

U.S. Environmental Protection Agency. 1980. Analysis of the Emission Inspection Analyzer. EPA-AA-IMS-80-S-A/B.

SECTION 2.0

ACCURACY OF READINGS

2.1 ANALYZER CALIBRATION ACCURACY

2.1.1 Technical Overview

Analyzer calibration accuracy refers to the degree of precision by which an instrument is able to determine the true concentration of a precision gas. While all components of the analyzer potentially influence accuracy, the reference is primarily to the bench, which is a term used for the main sample processing assembly of the analyzer including detectors, sampling tubes, processing boards, infrared sources, and power supply (see Subsection 1.4 for a description of these components). Accuracy is determined by the precision of the components in the bench. Beyond the inherent precision of the components other factors potentially affect the proper operation of this system. They include moisture, dust, temperature, vibration, altitude, electromagnetic interferences, power fluctuations, and zero and span adjustments.

2.1.2 Comparison of Specifications

A comparison of specifications for analyzer accuracy appears in Table 2-1. The specifications are stated in different formats making specifications more or less restrictive in different measurement ranges. The ETI specification is the least restrictive with respect to temperature range. Since analyzers in Missouri often would be operated outside of the 55° to 85°F temperature range, the narrow temperature range is a severe shortcoming. BAR 74 specifications are the least restrictive over the low measurement range. BAR 80 specifications are the most restrictive over the low measurement range and are the same as BAR 74 in the high measurement range. Section 207(b) specifications are slightly less restrictive than BAR 80 and EPA but more restrictive than BAR 74 or ETI. The impact of analyzer accuracy on the effectiveness of the inspection/maintenance program is quantitatively evaluated in Section 7.0.

TABLE 2-1. COMPARISON OF SPECIFICATIONS FOR ANALYZER ACCURACY

Standard	Specification
ETI	0-500 ppm HC: ±25 ppm. 500-2000 ppm HC: ±60 ppm, or ±5 percent of reading, whichever is greater. 0-2.5 percent CO: 0.1 percent, or ±5 percent of reading, whichever is greater. 2.5-10 percent CO: 0.3 percent, or ±5 percent of reading, whichever is greater. Temperature range: 55° to 85°F. Double values when outside of temperature range.
BAR 74	0-1000 ppm HC: ±30 ppm. 1000-2000 ppm HC: ±60 ppm. 0-5 percent CO: ±0.15 percent. 5-10 percent CO: ±0.30 percent. Temperature range: 35° to 110°F.
BAR 80	0-400 ppm HC: ±12 ppm. 400-1000 ppm HC: ±30 ppm. 1000-2000 ppm HC: ±60 ppm. 0-2 percent CO: ±0.06 percent. 2-5 percent CO: ±0.15 percent. 5-10 percent CO: ±0.30 percent. Temperature range: 35° to 110°F.
EPA	±5 percent of point. Temperature range: 35° to 110°F.
207(b)	200-220 ppm HC: ±15 ppm. 1.0-1.2 percent CO: ±0.1 percent. Temperature range: not given.

2.2 ZERO AND SPAN DRIFT

2.2.1 Technical Overview

Drift refers to the amount of meter reading change over a period of time. Zero drift refers to a change of zero reading. Span drift refers to a change in reading of a calibration point on the upper portion of each scale. The calibration points are established by adjusting the unit to calibration gases of known concentrations. Instrument zero drift can exceed ±3 percent of full scale at normal operating temperatures over a period of four hours. Temperature extremes generally serve further to degrade zero drift performance.

Subsection 1.4 explains the process by which the infrared beam is directed through the sample tube and focused on the detector. The detector senses the infrared energy as heat and transforms it into electrical voltage. Drift may occur due to the amplification of this small voltage. Subsection 1.4 also describes how this is minimized by converting the signal to a.c. by chopping the infrared beam with a rotating disc.

2.2.2 Comparison of Specifications

A comparison of specifications for zero and span drift appears in Table 2-2. The amount of meter reading change is most restrictive for the EPA specifications. Next most restrictive are the 207(b) and BAR 80 specifications. BAR 74 specifications are the least restrictive. The impact of emission analyzer drift specifications on I/M program effectiveness is quantitatively evaluated in Section 7.0.

2.3 HC HANGUP

2.3.1 Technical Overview

Hangup refers to the process of hydrocarbon molecules being absorbed, condensed, or by any other method removed from the sample flow prior to reaching the analyzer detector. It also refers to any subsequent desorbtion of the molecules into the sample flow when they are assumed to be absent. The main component of the analyzer that influences HC hangup is the flexible sample line. The operating environment in which the analyzer is to be used is important in keeping HC hangup to a minimum. Temperature and humidity extremes may affect the sample lines ability to transport the exhaust gas to the analyzer.

TABLE 2-2. COMPARISON OF SPECIFICATIONS FOR DRIFT

Standard	Specification
ETI	Zero: HC: <15 ppm in a 1-hour period. CO: <0.6 percent CO in a 1-hour period. Span: HC and CO: ±3 percent of reading for the first hour and ±2 percent of reading for second hour.
BAR 74	Zero and span: 0-1000 ppm HC: ±30 ppm HC in a 1-hour period. 1000-2000 ppm HC: ±60 ppm HC in a 1-hour period. 0-5 percent CO: ±0.15 percent in a 1-hour period. 5-10 percent CO: ±0.30 percent in a 1-hour period.
BAR 80	Zero: Shall not exceed ±12 ppm HC and 0.06 percent CO for 1-hour operation. Span: Shall not exceed ±12 ppm HC and 0.06 percent CO for first hour and shall not exceed ±8 ppm HC and 0.04 percent CO for the second hour of continuous operation.
EPA	Zero: HC: ±8 ppm HC for 1 hour. CO: ±0.04 percent CO for 1 hour. Time reduced to 30 minutes if analyzer is equipped with automatic zeroing system. Span: HC: ± 8 ppm HC for 1 hour. CO: ±0.04 percent CO for 1 hour.
207(b)	Zero and span drift shall not exceed ±0.1 percent CO and ±15 ppm HC on the lowest range capable of reading 1.0 percent CO or 200 ppm HC during a 1-hour period.

2.3.2 Comparison of Specifications

A comparison of specifications for HC hang-up appears in Table 2-3. It should be noted that all HC concentrations are measured as hexane. The ETI and BAR 74 specifications are identical while the BAR 80 specifications are more stringent. The BAR 80 specifications require that the HC hangup check procedure be completed at 15 and 30 seconds after a 2 minute sample has been taken as opposed to 30 seconds after a 1 minute sample for the ETI and BAR 74. The HC hangup must be less than 200 ppm HC for the ETI and BAR 74 specifications. The EPA specifications are the most restrictive in that the HC hangup must be less than 20 ppm HC before each test.

2.4 GAS AND ELECTRICAL INTERFERENCES

2.4.1 Technical Overview

Vehicle exhaust gases contain some components which are of no interest but which may affect measured readings of HC and CO. These can be defined as noninterest gases. The interference effects of various noninterest gases can be quite significant with respect to operating environment. Carbon dioxide and NO_2 are two of the most dominant interference gases. Subsection 1.4 describes how some of the interfering gases are treated at the detector.

Errors may also be caused by responses to electromagnetic sources and power supply variations. Common forms of electromagnetic sources are:

1. Radio frequency interference (RFI)
2. Very high frequency interference (VHF)

In addition to RFI and VHF, induction, line interference, line voltage and frequency variation, and static electricity need to be controlled. Interference is determined by exposing the analyzer to some, or all, of these conditions, depending on the standards to be adopted.

2.4.2 Comparison of Specifications

A comparison of specifications for gas and electrical interferences appears in Table 2-4. The specifications vary with respect to the number of interfering items and also the percent fluctuation that is allowed for the specific item being examined. The ETI specifications are the least restrictive with no criteria specified for electrical interference. The BAR 74 and BAR 80 specifications are the same for gaseous interferences but no

TABLE 2-3. COMPARISON OF SPECIFICATIONS FOR HC HANGUP

Standard	Specification
ETI	Less than 200 ppm HC (10 percent full scale) in 30 seconds after 1 minute sample.
BAR 74	Less than 200 ppm HC (10 percent full scale) in 30 seconds after 1 minute sample.
BAR 80	Less than 200 ppm HC (10 percent full scale) in 15 seconds after 2 minute sample. And 60 ppm HC in 30 seconds.
EPA	Less than 20 ppm HC (5 percent full scale) before each test.

TABLE 2-4. COMPARISON OF SPECIFICATIONS FOR GAS AND ELECTRICAL INTERFERENCE

Standard	Specification
ETI	Gaseous: 5 items: CO-0.05 percent CO interface limit. Interfering gas - 15 percent CO_2 in N_2, 1600 ppm hexane in N_2. HC-10 ppm HC interface limit. Interfering gas - 10 percent CO in N_2, 3 percent H_2O in air, and 3000 ppm NO in N_2. Electrical: No criteria specified.
BAR 74	Gaseous: 6 items: Interference shall not exceed ±1 percent full scale HC and CO for the following gases: 15 percent CO_2 in N_2, 1600 ppm HC in N_2, 10 percent CO in N_2, 3 percent H_2O vapor in air (saturated), 3000 ppm NO in N_2, and 10 percent O_2 in N_2. Electrical: No criteria specified.
BAR 80	Gaseous: 6 items: Interference not to exceed ±10 ppm HC or 0.05 percent CO (as measured on the low scale) for the following gases: 15 percent CO_2 in N_2, 1600 ppm HC in H_2, 10 percent CO in N_2, 3 percent H_2O vapor in air (saturated)(bubble method), 3000 ppm NO in N_2, and 10 percent O_2 in N_2. Electrical: 5 items: Interference not to exceed ±10 ppm HC or 0.05 percent CO (as measured on the low scale) for the following radiation sources: RFI, VHF, induction, line interference and line voltage, and frequency variation.
EPA	Gaseous: 3 items: Interference not to exceed 6 ppm HC or 0.02 percent CO (as measured on the low scale) for the following gases: 14 percent CO_2, saturated water at 40°C (101°F), and 100 ppm NO_2. Electrical: 6 items: Interference not to exceed 4 ppm HC or 0.02 percent CO (as measured on the low scale) for the following electronic interferences: RFI, VHF, induction, line interference, line voltage and frequency variation, static electricity (analog meters only, 10 ppm HC and 0.05 percent CO).

criteria are specified for electrical interferences with BAR 74. The EPA specifications are the most restrictive with respect to the number of electrical items tested but require only three items to be examined under gaseous interference.

2.5 LEAKS

2.5.1 Technical Overview

Leaks in the sample system are probably the source of the largest and most frequent errors that occur in emission measurement systems. This is because a leak is transformed directly into an error (i.e., a 15 percent leak is a 15 percent error). Leaks will normally occur in the vacuum side of the system and can be found in many places. The most common areas for leaks to occur are in the sample line and other sample transport components. Leaks may also occur due to improper operating or maintenance procedures while changing the particulate filter or maintaining the water trap.

2.5.2 Comparison of Specifications

A comparison of specifications for leak detection appears in Table 2-5. There is no value specified for leaks in the ETI or BAR 74 specifications. The BAR 80 specifications state that the sample system must be provided with a means of testing the portion of the sample system which is normally exposed to less than atmospheric pressure. This capability must be designed into the analyzer. Pass/fail criteria are specified. The EPA specification is more restrictive in that it requires a comparison of the span gas response introduced through the span network to the response of the same gas introduced through the probe and sample line. Weekly checks are required by EPA specifications while the frequency of field checking is not specified for BAR 80 specifications.

2.6 REPEATABILITY

2.6.1 Technical Overview

Repeatability refers to the instruments capability to provide the same value for successive measurements of the same sample. Analyzer repeatability is highly influenced by the accuracy of the unit. If the degree of precision by which an instrument is able to determine the true concentration of a gas is low, then the chances of repeatability are also diminished. Some of the same factors which may affect accuracy also affect repeatability. These include moisture, dust, temperature, vibration, electromagnetic interference, and power fluctuations.

TABLE 2-5. COMPARISON OF SPECIFICATIONS FOR LEAKS

Standard	Specification
ETI	No value specified.
BAR 74	No value specified.
BAR 80	The pass/fail criteria is based on dilution introduced by a leak causing an error of 10 ppm HC or 0.05 percent CO when 80 percent low range gas is being introduced at the probe. Frequency not specified.
EPA	3 percent of comparative gas readings, weekly.
207(b)	3 percent of comparative gas readings, weekly.

2.6.2 Comparison of Specifications

A comparison of specifications for repeatability appears in Table 2-6. The ETI, BAR 74, and BAR 80 specifications are identical and allow for a repeatability error of ±2 percent of full scale. EPA specifications are the least restrictive over higher readings allowing for an error of ±5 percent of point.

TABLE 2-6. COMPARISON OF SPECIFICATIONS FOR REPEATABILITY

Standard	Specification
ETI	Analyzer repeatability shall be within ±2 percent of full scale during five successive samples.
BAR 74	Analyzer repeatability shall be within ±2 percent of full scale during five successive samples.
BAR 80	Analyzer repeatability shall be within ±2 percent of full scale during five successive samples.
EPA	Analyzer repeatability shall be within ±5 percent of point.

SECTION 3.0

ANALYZER FEATURES AFFECTING MEASURED VALUES

3.1 TEMPERATURE AND HUMIDITY OPERATING RANGE

3.1.1 Technical Overview

Variations in temperature and humidity affect analyzer accuracy by affecting the performance of various components in the bench. Most serious is exposure of the analyzer to high temperature environments and to a lesser extent, low temperatures.

Various components in the bench are enclosed in insulated housings to keep the temperature of the component at a constant temperature to avoid temperature induced-changes in filter wavelength. The range in ambient temperatures affect the ability of the analyzer to maintain constant component temperatures. Minor changes in temperature of the components can be corrected with the span or zero adjustment. Greater change in temperature cannot be adjusted and cause inaccurate readings.

Excess water vapor in the exhaust gas, primarily caused by high humidity, tends to cause hydrocarbon deposits on the sampling tube walls causing internal light reflections which introduce substantial inaccuracy to the system. Most analyzer units have a water removal system (see Subsection 3.5).

3.1.2 Comparison of Specifications

A comparison of standards for temperature and humidity appears in Table 3-1. All four specifications are different with the ETI specification the least restrictive and the EPA being most restrictive. With regard to temperatures, ETI specifications list a relatively narrow temperature range of 55° to 85°F while the other specifications specify a range of 35° to 110°F. The BAR 80 specifications include an exposure to a 10 mph wind. The relative humidity range specification is 0 to 85 percent for ETI, BAR 74, and BAR 80, while EPA specifications require 0 to 100 percent.

Ambient temperatures in St. Louis often are outside of the 55° to 85°F range even inside auto repair facilities. This would limit the usefulness of ETI specification analyzers. Humidity

TABLE 3-1. COMPARISON OF SPECIFICATIONS FOR TEMPERATURE AND HUMIDITY

Standard	Specification
ETI	Temperature 55° to 85°F. For temperatures between 35° to 55° and 85° to 105° multiply the accuracy limits by 2.0. Relative humidity 0 to 85 percent, while exposed to winds up to 10 mph.
BAR 74	Temperature range 35° to 110°F, while exposed to 10 mph winds. Relative humidity 0 to 85 percent.
BAR 80	Temperature range 35° to 110°F, while exposed to 10 mph winds. Relative humidity 0 to 85 percent.
EPA	Temperature range 35° to 110°F. Relative humidity 0 to 100 percent (raining).

over 85 percent can affect analyzer accuracy during periods when temperatures exceed 80°F (Olson Laboratories 1977; Clemens 1981). Highly variable readings or machine failure result. An examination of two years of meteorological data for St. Louis (National Oceanic and Atmospheric Administration 1976-1977) revealed that there were no occurrences of 85 percent or greater humidity that coincided with temperatures in excess of 80°F. Therefore, the 0 to 85 percent humidity range appears adequate.

3.2 WARMUP TIME AND LOCKOUT

3.2.1 Technical Overview

Warmup time refers to the period from power-on to stabilized operation for an emissions analyzer. As noted in previous sections, certain components in the bench portion of the emissions analyzer are very temperature sensitive and must be maintained at a constant temperature to perform accurately. These components must be heated or cooled to specified temperatures. The warmup time encompasses the heating or cooling period.

Analyzer designs vary with respect to indicators that the analyzer is properly warmed-up. Some analyzers have no indication at all. Other analyzers contain indicator lights. In both these cases, emission measurements can be made before the warmup period is complete. A third category of analyzer contains a lockout system which prohibits premature operation usually by locking the metering device to zero or full scale.

3.2.2 Comparison of Specifications

A comparison of specifications for warmup time is shown in Table 3-2. ETI and BAR 74 specifications are very similar with a slight difference in ambient temperature range. BAR 80 requirements change the warmup time from 30 to 15 minutes over a slightly different temperature range and also require a lockout feature. The EPA specification does not use the time parameter. The system must have a lockout device until certain component temperatures are achieved within the analyzer. The lockout feature effectively prohibits premature analyzer operation.

3.3 PROBE DESIGN

3.3.1 Technical Overview

The probe is the device inserted into the tailpipe to draw the exhaust sample. There are several issues regarding probe design, most centering around sample dilution. If the probe is not inserted far enough, part of the gas sample drawn may be

TABLE 3-2. COMPARISON OF SPECIFICATIONS FOR WARMUP TIME AND LOCKOUT

Standard	Specification
ETI	The analyzer shall reach stabilized operation within 30 minutes from power on over the temperature range of 55° to 105°F.
BAR 74	The analyzer shall reach stabilized operation within 30 minutes from power on over the temperature range of 70° to 110°F.
BAR 80	The analyzer shall reach stabilized operation within 15 minutes from power on over the temperature range of 75° to 105°F. Must have lockout capability.
EPA	The analyzer must have a warmup lockout feature with indicators. No specific warmup time is specified. The lockout feature shall prevent operation of the printer and readout meter until the system is warmed up.

ambient air as opposed to exhaust gas. The amount of dilution is directly transmitted into measurement error, i.e., 15 percent dilution will cause the reading to be 15 percent too low. There is considerable controversy in the technical literature about how far a probe must be inserted to avoid sample dilution.

The first issue is the requirement for a device to secure the probe to the tailpipe. When the analyzer is in use, it is common practice for the analyzer operator to insert the probe and return to the front of the car to make adjustments and/or record test results. Exhaust pressure, vibration and the weight of the sample line act to push the probe out of the tailpipe causing possible sample dilution. Many tailpipes are bent or have a screen very near the opening, limiting the depth of insertion possible with a rigid probe. A flexible portion on the end of the probe allows deeper insertion. Even with a flexible end, some tailpipes will not allow adequate insertion without a tailpipe extender (a straight tube which fits tightly over the end of a tailpipe allowing the gas sample to be drawn from within the extender). The requirement for a handgrip is a user convenience necessitated by the heat of the exhaust and the metal probe. Other specifications for the probe tip relate to calibration procedures and leak check procedures.

3.3.2 Comparison of Specifications

A comparison of specifications for probe design is shown in Table 3-3. ETI specifications are the least restrictive in general and no requirement for tailpipe insertion is given. BAR 74 specifications are similar except for the 6 inch probe insertion requirement. BAR 80 and EPA specifications are very similar in nature and are more restrictive than ETI or BAR 74. BAR 80 specifies a 12 inch insertion and EPA specifies a 16 inch insertion. Both contain similar requirements for retention, hand grips, serviceability, tailpipe extenders and provisions for leak checks.

Research regarding the required depth of probe insertion to insure an accurate reading gives different results. In general, a 12 inch minimum is suggested to insure against sample dilution.

3.4 SAMPLE LINE DESIGN

3.4.1 Technical Overview

Sample line variables deal with resistance of the line to oil which is commonly found around testing locations, composition of the line such that the hangup is minimized (see subsection 2.3), flexibility at low temperatures, and length.

TABLE 3-3. COMPARISON OF SPECIFICATIONS FOR PROBE DESIGN

Standard	Specification
ETI	The probe should not slip out of a vehicle tailpipe when in use for analysis. A thermally insulated comfortable handgrip shall be provided on the sample probe handle. Probe design should prevent errors due to dilution.
BAR 74	Same as ETI, plus the probe should be flexible enough to extend into a curved tailpipe 6 inches.
BAR 80	Retention - probe must incorporate a position means of retention to prevent its slipping out of tailpipes when in use. Handgrip - Same as above. Flexibility - probe shall be flexible enough to extend into a 1-1/2 inch diameter tailpipe having a 3 inch centerline 90° radius bend. The probe insertion depth must be 12 inches or greater. Probe serviceability - probe tip and flex section must be replaceable as a unit. Calibration gas introduction - probe tip must be designed to permit the introduction of calibration gas from a 1/2 inch I.D. flexible rubber hose inserted over the tip. Anti-dilution - the device may be supplied by the manufacturer to prevent sample dilution. Probe cap - cap must be provided for performing a system leak check.
EPA	Very similar to BAR 80 except the probe insertion depth is 16 inches.

3.4.2 Comparison of Specifications

Specifications for sample line design are shown in Table 3-4. The four standards are not radically different. All specify a composition minimizing HC hangup and resistance to oil. Specifications for length vary with BAR 80 requiring the longest line.

3.5 WATER REMOVAL SYSTEM

3.5.1 Technical Overview

Most nondispersive infrared analyzers (NDIR) type emission analyzers cannot accept moisture-laden exhaust and operate properly. Accuracy can vary by 10 percent depending on the amount of moisture removed. Almost all analyzers use a momentum type water trap. Specifications deal primarily with serviceability to the analyzer operator.

3.5.2 Comparison of Specifications

Specifications are compared in Table 3-5. They are quite similar. All require that the device be self draining. BAR 74 and EPA require that the collection vessel be visible.

3.6 CONVERSION FACTOR

3.6.1 Technical Overview

The term conversion factor refers to the propane to hexane conversion factor that accounts for the difference in analyzer response between propane and hexane. It is also referred to as a "C" factor or a P.E.F. (propane equivalence factor). Emission analyzers measure hexane (C_6H_{14}) in exhaust. Calibration gas is typically propane. During instrument gas calibration, the HC value is determined by multiplying the propane concentration by the conversion factor.

The conversion factor varies by individual instrument, even when the instruments are of the same design. Therefore, a factor is usually marked on each analyzer.

3.6.2 Comparison of Specifications

Specifications for the conversion factor are compared in Table 3-6. With the exception of BAR 74 specifications which do not regulate the factor, the other specifications are similar. BAR 80 specifications require that each instrument be permanently labeled as opposed to writing the factor on a sticker which is the common practice. This is a protective measure to minimize

TABLE 3-4. COMPARISON OF SPECIFICATIONS FOR SAMPLE LINE DESIGN

Standard	Specification
ETI	The flexible line shall be oil resistant and of such composition that HC hangup will be minimized.
BAR 74	Same as ETI, plus the line length shall be at least 20 feet if the instrument is placed at the front of the vehicle. The line may be shorter if the unit is placed at the rear of the vehicle, provided a remote meter readout is included.
BAR 80	Flexible line shall be oil resistant and of such composition that HC hangup shall be minimized. The sample line shall resist permanent crushing and kinking and will be unaffected by exhaust gas temperatures. The sample line shall remain flexible enough to coil the hose into at least a 24 inch diameter roll at 60°F. The line length shall be at least 25 feet.
EPA	Sample line shall not alter the exhaust sample and shall minimize HC hangup. Sample line shall be sufficiently flexible at the temperatures to be encountered during vehicle testing to allow normal inspection operations. Sample line length is 15-25 feet.

TABLE 3-5. COMPARISON OF SPECIFICATIONS FOR THE WATER REMOVAL SYSTEM

Standard	Specification
ETI	The water removal system shall either be continually selfdraining or not require emptying more than once during the normal work day or be provided with an alarm to indicate needed draining.
BAR 74	The water removal collection vessel shall be visible to the operator. The water removal system shall be located as low as possible relative to the analyzer and shall either be continually selfdraining or not require emptying more than once during the normal work day.
BAR 80	The water removal system shall be continually selfdraining.
EPA	A water trap shall be included in the sample system. The trap shall be selfdraining and visible to the operator. The sample system shall be designed to prevent condensable water from occurring in the sample system downstream of the water trap.
207(b)	The exhaust sampling system shall include a moisture separator.

TABLE 3-6. COMPARISON OF SPECIFICATIONS FOR THE PROPANE TO HEXANE CONVERSION FACTOR

Standard	Specification
ETI	For all instruments this factor will fall within the range 0.46 to 0.58. This number must be marked on the exterior surface of the instrument.
BAR 74	Not specified.
BAR 80	Each instrument shall be permanently labeled with its correction factor carried to three places. Filter factor range for HC shall be limited between 0.490 and 0.540.
EPA	The mean propane to hexane conversion factor for each analyzer sold as a pass/fail inspection analyzer shall be between 0.48 and 0.56 for each test point.

changing the conversion factor to make an analyzer calibrate within specified levels.

3.7 LOW FLOW INDICATOR

3.7.1 Technical Overview

Low flow refers to a condition wherein an adequate amount of sample gas is not being drawn into the analyzer to obtain an adequate reading. A low flow condition could result in an abnormally low measured concentration. Low flow can be caused by many factors including the water removal system, the particulate removal system, the sample line, or a component malfunction. On most analyzers, a low flow indicator light indicates a low flow condition.

3.7.2 Comparison of Specifications

Specifications for low flow indicator systems are compared in Table 3-7. The specifications for low flow indicators are very similar. All require a flow meter (or equivalent) or an indicator that is activated due to poor response time and/or meter error.

3.8 METER DESIGN

3.8.1 Technical Overview

Variables regarding meter design are:

1. Analog or digital
2. For analog meters, increments on meter
3. Distance at which the meter can be read
4. For analog meters, scale indicator lamps

Metering devices can be analog (meters with a printed scale and indicator needle) or digital. Analog devices are potentially less accurate since they require the operator to read a value off a scale leading to a possible error due to parallax or misinterpretation of the numerical values. Two ranges are usually required so that readings on the low end of the scale can be more accurately made. Digital devices, while more costly, display a measured value and require no interpolation by the operator. Two ranges are not required.

TABLE 3-7. COMPARISON OF SPECIFICATIONS FOR LOW FLOW INDICATOR

Standard	Specification
ETI	The sample system will be equipped with a flow indicator. The indicator should give a warning indication before either the response time has exceeded 15 seconds or the flow reduction has resulted in errors 3 percent of full scale on the high range.
BAR 74	The sampling system shall be equipped with a flow meter (or equivalent) which will indicate sample flow degradation sufficient to cause an error greater than ±3 percent full scale.
BAR 80	The sampling system shall be equipped with a flow meter (or equivalent) which shall indicate sample flow degradation when meter error exceeds 3 percent of full scale, or causes system response time to exceed 13 seconds to reach a 90 percent value, whichever is less.
EPA	The analyzer must have a low sample flow indicator. The low flow indicator shall be activated when the sample flow rate is decreased to a point that would not allow the analysis system to meet the response time specifications.

Analog meters must be graduated in increments to facilitate observing the measured values. Different increments are specified for the high and low scale.

Some of the specifications require that the display be of sufficient size to be read from a specified distance. This eliminates problems of operators misreading the value from a distance or having to approach the analyzer to obtain the reading.

Certain specifications also require scale indicator lights. This is critical on analog devices where two scales are printed on the same meter. Misinterpretation of the scale being used can cause a significantly different value to be recorded.

3.8.2 Comparison of Specifications

Specifications for meter design are shown in Table 3-8. ETI, BAR 74, and BAR 80 specifications are similar. All specifications allow analog or digital meters. On the high scale (see Subsection 3.9), analog meters must be graduated in increments of 50 ppm of HC or less, and 0.2 percent of CO or less. For the low scale, CO measurement requirements vary from 0.05 percent to 0.20 percent, while HC requirements vary from 10 ppm to 25 ppm. EPA specifications state only that meters be appropriately scaled. The distance at which the reading must be discernable varies from 8 feet (ETI) to 10 feet (BAR 74 and BAR 80) to 15 feet (EPA). BAR 80 and EPA specifications require range indicator lights.

3.9 INSTRUMENT RANGE

3.9.1 Technical Overview

Instrument range refers to the range of values that can be displayed on an analyzer. For analog devices, (see Subsection 3.8) two scales are usually required, a low scale and a high scale. A low scale is required so that more precise readings can be taken at low measured values. The high scale spans the whole range of values. For digital devices, a specified range of values must be available as opposed to a high scale and low scale.

3.9.2 Comparison of Specifications

Specifications for instrument range are compared in Table 3-9. High scale ranges of 0 to 10 percent CO and 0 to 2000 ppm HC are required in all specifications for analog devices. A greater range of CO values is specified for the low scale ranging from 0 to 2 percent CO (BAR 80 and EPA), 0 to 2.5 percent CO (ETI), and 0 to 5.0 percent CO (BAR 74). For HC, low scale value requirements range from 0 to 400 ppm HC (BAR 80 and EPA), 0 to 500 ppm HC (ETI), and 0 to 1000 ppm HC (BAR 74).

TABLE 3-8. COMPARISON OF SPECIFICATIONS FOR METER DESIGN

Standard	Specification
ETI	Reading must be discernable at 8 feet for metered type devices. The HC scale having a 2000 ppm range will be graduated in increments of 50 ppm or less. The low HC scale will be graduated in increments of 25 ppm or less. The 0-10 percent scale will be graduated in increments of 0.2 percent CO or less. The low CO scale will be graduated in increments of 0.1 percent CO or less below 2 percent and 0.2 percent CO or less above 2 percent. Digital readout systems are acceptable provided the resolution equals or exceeds the scale graduation indicated previously.
BAR 74	Reading must be discernable at 10 feet. High scale shall be graduated in increments of 0.2 percent CO and 50 ppm HC or less. The meter face of the low scale shall be graduated in increments of 0.1 percent CO and 25 ppm HC or perhaps less if the scale covers less than 5 percent CO and 1000 ppm HC.
BAR 80	Reading must be discernable at 10 feet with 0.250 inch high numerals of bold design. The meter face of the high scale shall be graduated in increments of 0.2 percent CO and 50 ppm HC or less. The meter face of the low scale shall be graduated in increments of 0.05 percent CO and 10 ppm HC or less. Scale indicator lamps are required. Digital meter increments shall not be greater than 0.05 percent for CO and 10 ppm for HC or less than 0.01 percent for CO and 1 ppm for HC.
EPA	Reading must be discernable at 15 feet. Readout devices (digital or analog) shall be scaled and capable of reading negative values up to -5 percent of full scale for each range regardless of operational mode. All multi-range analyzers shall have range indicating lights.

TABLE 3-9. COMPARISON OF VALUES FOR INSTRUMENT RANGE

Standard	Specification
ETI	Dual scale coverage is prescribed. HC 0 to 2000 ppm CO 0 to 10% 0 to 500 ppm 0 to 2.5% Digital readout devices can have a single scale provided they meet the resolution requirements.
BAR 74	Dual scale coverage is prescribed. HC 0 to 2000 ppm CO 0 to 10% 0 to 1000 ppm 0 to 5% Digital readout devices can have a single scale provided they meet the resolution requirements.
BAR 80	Dual scale coverage is prescribed. HC 0 to 2000 ppm CO 0 to 10% 0 to 400 ppm 0 to 2% If digital panel meters are used, the respective ranges shall be 0 to 10 percent for CO and 0 to 2000 ppm for HC.
EPA	Dual scale coverage is prescribed. HC -50 to 1000 ppm CO -0.5 to 10% -20 to 400 ppm -0.1 to 2% Digital readout devices can have a single scale provided they meet the resolution requirements.

3.10 RESPONSE TIME

3.10.1 Technical Overview

Response time is defined as the reaction time between a change in concentration at the inlet to the sample system and the time the analyzer indicates a given percentage of that change. The basic problem associated with response time is the operator recording the concentration too soon after inserting the probe or making an engine adjustment when the probe is already inserted.

3.10.2 Comparison of Specifications

Specifications for response time are shown in Table 3-10. ETI and BAR 74 specifications are the same with BAR 80 specifications being slightly more restrictive. EPA specifications require that 95 percent, as opposed to 90 percent, of the final reading be reached within a minimum time, but the minimum time of 14 seconds is 4 to 6 seconds longer than the ETI, BAR 74, and BAR 80 specifications.

3.11 INTERNAL OR EXTERNAL GAS FOR CALIBRATION

3.11.1 Technical Overview

Analytical gases that are used to adjust or return the analyzer response characteristics to those determined by the calibration gases are designated as span gases. Zero gas is an analytical gas that is used to set the analyzer response at zero.

3.11.2 Comparison of Specifications

A comparison of specifications for analyzer gases appears in Table 3-11. The ETI and BAR 74 specifications are similar in that they only require the analyzer to have the external fittings which are necessary for calibration. The calibration containers are not required to be an integral part of the unit. In addition to the external calibration gas port, the BAR 80 and EPA specifications require the span gas container to be an integral part of the analyzer unit.

There are advantages and disadvantages to both external and internal gas systems. If the system is external, the calibration can be performed through the probe thus testing the probe, sample line and analyzer. The disadvantage is that for each calibration, the equipment must be assembled. This is a deterant because of the time it takes and because of potential inaccuracies if the equipment is not assembled correctly. With an internal system, the disadvantages of an external system are overcome; the procedure is easy to perform and no equipment assembly is required.

TABLE 3-10. COMPARISON OF VALUES FOR RESPONSE TIME

Standard	Specification
ETI	Concentration indication must reach 90 percent of the final stabilized reading within 10 seconds.
BAR 74	Concentration indication must reach 90 percent of the final stabilized reading within 10 seconds.
BAR 80	Concentration indication must reach 90 percent of the final stabilized reading within 8 seconds.
EPA	Concentration indication must reach 95 percent of the final stabilized reading within 14 seconds.
207(b)	Concentration indication must reach 95 percent of the final stabilized reading within 15 seconds.

TABLE 3-11. COMPARISON OF SPECIFICATIONS FOR INTERNAL/EXTERNAL GAS SYSTEMS

Standard	Specification
ETI	Instruments requiring gas calibration shall be equipped with a suitable calibration gas port.
BAR 74	Fittings for external gas connection are required. Gas calibration containers may or may not be an integral part of the instrument system.
BAR 80	Fittings for external gas connection are required. In addition, the analyzer shall incorporate an integral gas system for calibrating high range scales of HC and CO. Probe tip must be designed to permit the introduction of calibration gas.
EPA	Fittings for external gas connection are required. The analyzer shall incorporate an integral gas system for calibration, preferably at 1.5 percent CO and 600 ppm HC.

Conversely, the calibration is performed internally and does not involve the probe on sample line. Thus, an internal calibration system should be coupled with a leak check procedure (Subsection 2.5).

Quality assurance procedures are examined in depth in another PEDCo report (PEDCo 1981).

REFERENCES

Clemens, W. 1981. Telephone conversation with W. Clemens, U.S. Environmental Protection Agency, Inspection and Maintenance Staff, Emission Control Technology Division, Office of Mobile Source Air Pollution Control. Ann Arbor, Michigan.

National Oceanic and Atmospheric Administration. January 1976-December 1977. Local Climatological Data, Monthly Summary--St. Louis. Asheville, North Carolina.

Olson Laboratories, Inc., Ann Arbor, Michigan. 1977. Vehicle Exhaust Emission Instruments Evaluation. Prepared for U.S. Environmental Protection Agency, Ann Arbor, Michigan. Publication No. EPA-460/3-77-014.

SECTION 4.0

CONSTRUCTION, MATERIALS, AND DEPENDABILITY

4.1 MATERIALS AND FINISH, VIBRATION AND SHOCK PROTECTION

4.1.1 Technical Overview

Most analyzers are used in automotive repair facilities and can be subject to certain abuses such as exposure to corrosive materials, vibrations, and shock.

4.1.2 Comparison of Specifications

Specifications for materials and finish (Table 4-1) are similar for all four sets of specifications. Materials and finish must be resistant to corrosive materials likely to be found in an auto repair facility.

Specifications for vibration and shock are also very similar. EPA specifications could be slightly more restrictive since they define "unaffected".

4.2 PARTICULATE FILTER

4.2.1 Technical Overview

All analyzers require a particulate removal device to remove particulate from the exhaust gas sample. Often the particulate filter is combined with the water removal system. The particulate is removed with a filter that requires periodic changing. Failure to change the filter would result in a low flow condition (Subsection 3.7). A potential problem with the system can result if the operator improperly installs the filter resulting in potential leaks (Subsection 2.5).

4.2.2 Comparison of Specifications

A comparison of specifications for particulate filters (Table 4-2) indicates that the ETI and BAR 74 specifications are the same requiring only that there be a replaceable particulate filter. BAR 80 specifications further require that the filter be adequate to operate for a 2-hour period measuring gas levels of

TABLE 4-1. COMPARISON OF SPECIFICATIONS FOR MATERIALS, FINISH, VIBRATION, AND SHOCK PROTECTION

Standard	Specification
ETI	Materials and finish resistant to corrosive type materials found in automobile service centers and sufficiently durable to withstand environmental conditions there. Vibration and shock - system operation shall be unaffected by the vibration and shock encountered under normal operating conditions in an automotive service center.
BAR 74	Material and finish - same as ETI. Vibration and shock - same as ETI, plus instruments, motors, and pumps shall be shock mounted as necessary to absorb any vibrations which might effect the system operation.
BAR 80	Materials and finish - same as ETI. Vibration and shock - same as BAR 74.
EPA	Materials and finish - same as ETI. Vibration and shock - all analyzer and system performance checks must be met during vibration and shock test and the span shift cannot be more than 2 percent full scale of low scale.

TABLE 4-2. COMPARISON OF SPECIFICATIONS FOR PARTICULATE FILTERS

Standard	Specification
ETI	The sampling system shall be equipped with a replaceable particulate filter(s) as required to maintain the operating performance of the analytical and sampling system.
BAR 74	Same as ETI.
BAR 80	The sampling system shall be equipped with reusable or inexpensive replaceable filter elements of adequate size to permit uninterrupted use for at least a 2-hour period while continually measuring exhaust gas at 800 ppm HC level. Filter bowels shall be transparent. Filter elements shall be visible from the exterior of the instrument.
EPA	Particulate filters shall be included in a sample system. If the filter is on a vacuum side of the system, it should be leak checked every time a filter is changed. The filter element and filter system shall be designed to prevent particulates larger than 5 microns from entering the sample cell of the analyzer.

800 ppm HC and that the system be visible from the exterior of the instrument. The EPA specification is the most restrictive. While there is no visual requirement, the system must prevent particulates larger than 5 microns from entering the sample cell and the instrument manual must indicate that the system be leak checked every time a filter element is changed.

4.3 PUMP

4.3.1 Technical Overview

An exhaust gas sample pump is required to create the air flow through the analyzer. The main area of concern about pumps is useful life. Beyond durability, the pump should be located upstream of the optical bench to help prevent the possibility of dillution air leaks and should have a pump control switch to enable analyzer standby. The last feature is required so that the analyzer can be left on all day (avoiding warmup time) without running the motor and drawing gas through the analyzer.

4.3.2 Comparison of Specifications

Pump specifications (Table 4-3) are very similar. All require a design which will enable 2000 to 2500 hours of operation or about 1 year of operation (about 2000 hours assuming 8 hours of operation each weekday). Only BAR 80 specifications require the pump control switch and the pump location upstream from the bench.

4.4 DEPENDABILITY

4.4.1 Technical Overview

There are no specifications for dependability in any of the four national sets of specifications other than the pump requirement. No reliable studies are available which compare the dependability of various analyzers under long-term field operating conditions.

Some preliminary conclusions can be made based on conversations with analyzer operators. The analyzer is a sophisticated instrument that requires specialized skills to repair. Gas station personnel are seldom capable of analyzer repair. The number of organizations that can provide repair services are few. In larger cities with I/M programs, most major analyzer manufacturers have a service system. However, the number of analyzers in operation in one area may not justify, to the manufacturer, a large service department. Some independent organizations do

TABLE 4-3. COMPARISON OF SPECIFICATIONS FOR PUMPS

Standard	Specification
ETI	The pump should be designed to operate for 2500 hours while sampling air in the operating condition encountered in the instrument. It should also be able to survive 2500 test exposures of 2 minutes each in normal exhaust gas while operating in an instrument.
BAR 74	Minimum operational life of 1 year with no mechanical or electrical failure. Manufacturer shall furnish pump life test data.
BAR 80	Exhaust gas sample pump shall be shock mounted. A minimum operational life of 2000 hours is required. A pump control switch shall be incorporated to enable analyzer standby and gas checks with the pump off. The pump should be downstream of the bench.
EPA	The sample pump shall be designed for at least a 2000 hour life of continuous duty.

repairs. In general, analyzer operators feel that repair costs are not very competitive, thereby leading to unduly high repair charges. Sufficient data not are available to validate or invalidate this claim.

Analyzer technology is relatively new and few NDIR analyzers have been on the market more than a short period of time. Manufacturers have discovered design flaws in some earlier instruments and have often corrected the design problem in new units and in some cases retrofitted old units. BAR 80 units are just becoming available, while EPA units are still in development. Some problems with newly designed equipment would seem inevitable. Instrument warranties on existing machines are usually a 1-year manufacturers warranty for parts and labor.

SECTION 5.0

ADDITIONAL ANALYZER FEATURES FOR DECENTRALIZED PROGRAMS RECOMMENDED BY EPA

The EPA has recommended that states implementing a decentralized I/M program add computer capability to the basic units described in preceding sections. In general, these are fail-safe features that automatically control functions that would normally be required of the operator. These functions include automatic zero/span check (electrical and gas), automatic leak check, and automatic HC hangup check. These checks are made automatically at prescribed intervals. If the machine fails any test, it becomes inoperative. In contrast, these checks may or may not be performed on a noncomputerized model, by an operator who may or may not correctly respond to the results of the check. In addition to these computerized checks, an automatic read system, dual tailpipe system, automatic test sequence, printer, vehicle diagnosis, anti-tampering, and system diagnostic testing capabilities are recommended.

These features require an onboard microprocessor. Only one such unit with some of the features described above is commercially available at this time. The State of New York contracted with Hamilton Test Systems to produce a computerized unit. Similar arrangements could probably be made with this manufacturer and/or others given sufficient lead time.

Because these automated features all require a microprocessor they are evaluated as a single option.

5.1 TECHNICAL OVERVIEW

5.1.1 Automatic Zero/Span Check

A timer is installed in the analyzer and at prescribed intervals, electrical span checks and gas span checks are required. At the prescribed interval, readout devices are driven to full scale until appropriate procedures are followed to complete the check. If the instrument passes the check, the instrument returns to normal operation. If it does not, it remains inoperative and an indication of analyzer malfunction is displayed.

5.1.2 Automatic Leak Check

This system is similar to the zero/span check. A leak check is automatically performed at specified intervals. Failure causes the readout to be driven to 100 percent of full scale and a fail indicator to be displayed.

5.1.3 Automatic Hang/up Check

An HC check will be automatically be made before each test. Failure to pass the test will cause the unit to become inoperative.

5.1.4 Automatic Read System

Without this system, slight variations in displayed concentrations will result as long as the probe is in place. This system will begin to integrate or average the values 17 seconds after the test has begun and will continue to do so for 15 seconds. The analyzer displays the integrated value.

5.1.5 Dual Tailpipes

This system allows values from two tailpipes on the same car to be averaged.

5.1.6 Automatic Test Sequence

For tests with more than one mode (e.g., idle and 2500 RPM), the system identifies the integrated value for each mode, makes a pass/fail decision, and either prints or stores the result until the end of the test sequence.

5.1.7 Printer

Following each test the following information is printed: date, inspection facility number, instrument serial number, inspection test number, HC and CO standards, integrated HC and CO values, and pass/fail indication.

5.1.8 Vehicle Diagnosis

The vehicle diagnosis system allows readings to be displayed continuously (as in a manual system) to allow for vehicle diagnosis. During this period, the printer, the automatic data collection system, and the automatic read system are inoperative.

5.1.9 AntiTampering and System Diagnostic Testing

All analyzer adjustments (zero/span check, antidilution limits, span gas concentrations, etc.) are put in a tamper proof box sealed with a gummed lable, braided wire and crimpted lead seal, or similar device.

5.2 EVALUATION

Most of the additional analyzer features for decentralized programs recommended by EPA are to protect against improper analyzer operation, i.e., failure to perform quality assurance procedures. A quantitative evaluation of the improvement in the quality of the data generated with the EPA recommended features would require long-term evaluation of I/M programs with and without the added features. No such long-term evaluations have been performed. In fact, no analyzer is commercially available with all these features with which to perform the evaluation.

While no such data is available, it is reasonable to assume that all analyzer operators would not perform all quality assurance procedures. However, a quantitative evaluation comparing incremental cost versus incremental data validity cannot be made. Quality assurance procedures are evaluated more fully in another PEDCo report (PEDCo 1981).

REFERENCES

PEDCo Environmental, Inc. 1981. An Evaluation of Quality Assurance Procedures for the Missouri Inspection/Maintenance Program.

SECTION 6.0

ANALYZER AVAILABILITY

6.1 RANGE OF ANALYZERS AVAILABLE

Units suitable for an inspection/ maintenance program are generally referred to as nondispersive infrared analyzers (NDIR). Manufacturers typically produce a freestanding unit with CO and HC measurement capability, as well as units wherein the emission analyzer is part of a unit which contains other automotive diagnositc equipment such as scopes, tachometers, voltmeters, etc.

Emission analyzers are listed in Table 6-1 by manufacturer, specifications they meet and price. Only the basic unit is listed (without other diagnostic equipment). In certain cases, the same unit is marketed under different trade names such as Allen and Rotunda.

Most units that meet BAR 74 specifications would also meet ETI specifications. Most BAR 74 units appear to also meet Section 207(b) requirements while others do not meet accuracy requirements. Analyzer response time is also a question (see note under BAR 80 unit). The range of costs for ETI/BAR 74 units is $2500 to $4170.

The range of costs for BAR 80 units is $4995 to $6950. All BAR 80 units appear to meet 207(b) requirements. The only reservation concerns analyzer response. Section 207(b) requires a response of 95 percent of the full reading within 15 seconds. Most manufacturers report response tests in terms of 90 percent of reading in 6 to 10 seconds, depending on the manufacturer. With the exception of the Marquette 42-090, no independent test data is available to verify adherance to the 95 percent of reading in 15 seconds, 207(b) specification.

6.2 SELECTING THE ANALYZER

States with decentralized programs have taken one of two approaches in selecting analyzers to be used in their I/M program.

The first approach is to adopt a national set of specifications and allow any manufacturer to produce units that will meet

TABLE 6-1. ANALYZER AVAILABILITY

Manufacturer	Cost, dollars			EPA recommended decentralized features	Appears to meet 207(b) requirements[g]
	ETI/ BAR 74	BAR 80	EPA		
Allen Group Test Products					
Allen[a]					
23-360	3675				X
23-390		5500			X
Bear Automotive					
Marquette[c]					
42-080	3061				X
42-090		5500			X
Environmental Tectonics					
IIIC	2500				
FMC Corporation					
Autoscan[b]					
805	3550			5	X
Hamilton Test Systems					
Autosense					
600 (2 gas)	4170	4995			X
CVIS[d]		5850		7, 8	X
KAL-EQUIP					
5011		n.a.[f]			X
Peerless					
675	2995				X
Snap-on-Tools					
MT497AS	3592				X
Sun					
EPA-75	4045				X
MGA-90		6950			X

[a] Allen Testproducts also distributes analyzers under the AMSERV, MTSE and Rotunda logo.

[b] FMC Corporation also distributes analyzers under the Rotunda and Atlas logo.

[c] Bear Automotive also distributes analyzers under the Atlas and Rotunda logo.

(continued)

TABLE 6-1 (continued)

[d] Automatic data collection and storage realized.

[e] Sun also manufacturers analyzers for Ford Motor Company (Rotunda) and Atlas Supply Corporation. The units sold under "Rotunda" and "Atlas" are identical to those sold by Sun Electric.

[f] KAL-EQUIP also distributed analyzers under the NAPA BALKAMP logo.

[g] Section 207(b) response requirement of 95 percent of reading within 15 seconds is not definitely met. Manufacturers specifications indicate a response of 90 percent of reading in 6 to 10 seconds, depending on manufacturer.

EPA RECOMMENDED DECENTRALIZED FEATURES

1. Automatic zero span check.
2. Automatic leak check.
3. Automatic hangup check.
4. Automatic read system.
5. Automatic test sequence.
6. Dual tailpipes.
7. Printer.
8. Vehicle diagnosis.
9. Antitampering.
10. System diagnostic testing.

that set of specifications. Since the manufacturers design and market their analyzer toward a specific set of specifications, a variety of units is immediately available to the I/M program. Examples of states taking this approach are Nevada and Rhode Island.

The second approach is for a state to compile their own specifications such as in New York. Because of the uniqueness of the specifications, no analyzers were being manufactured to meet the specifications. To insure that an adequate number of units would be available, it was necessary to contract with one manufacturer to build the units and only the one type of analyzer can be used in the New York program. While this approach allows the state to customize their specifications, it requires a significant lead time (to contract with a manufacturer and to have the units designed and produced), and eliminates other analyzer manufacturers from supplying units for the program.

Some modification from the first approach is possible if slight changes to the national specifications are made to which manufacturers can respond immediately. An example would be modifying BAR 74 specifications for the probe (6 inches in length) to the BAR 80 specifications for the probe (12 inches). Because many manufacturers market both a BAR 74 and a BAR 80 unit, the manufacturer can make production modifications that allow BAR 80 probes to be included with BAR 74 units.

6.3 CERTIFICATION OF UNITS

States that allow any manufacturer to participate in the I/M program (first approach in Subsection 6.2) have a certification process to insure that each analyzer used in the I/M program meets the adopted specifications. The certification processes vary slightly but generally require at least three elements:

1. Data by independent testing labs to prove that the instrument meets specifications mandated by the state.
2. Instrument description including operation, models and prices, schematics and photographs, and instruction manual.
3. Business status verifying that the manufacturer is viable to manufacture, warrant, and repair the analyzer.

Certification is given to a particular unit for a specified time and can be revoked by the state under certain conditions. A list of certified units is published by the state and distributed to all prospective testing locations. The testing locations are free to choose from all certified units.

SECTION 7.0

EVALUATION OF ANALYZER SPECIFICATIONS

7.1 EFFECT OF MEASUREMENT ERROR ON PROGRAM STRINGENCY

7.1.1 Technical Overview

The four sets of analyzer specifications were used to determine estimates in the following three areas:

1. The range of measurement error associated with each set of specifications.
2. The effect these errors could have on the number of cars passing or failing in the proposed I/M program.
3. The effect that the change in the pass/fail distribution of motor vehicles would have on the overall I/M program effectiveness in meeting air quality goals.

Each set of specfications was evaluated to calculate the maximum measurement error that could be expected, based strictly on the specifications. The calculated error values do not include any errors due to the operator. This limitation is critical since operator error could double or triple the calculated error values (see Subsection 7.2).

Using the calculated measurement errors, an approximate three standard deviation error band (3σ) was assigned to each set of specifications. These error bands were used to determine the effect of measurement error on the distribution of passing or failing vehicles during the proposed Missouri I/M program.

Using these results, it was then possible to estimate the measurement error impact on the proposed program stringency, and thus program effectiveness in meeting air quality goals.

The following subsections present the results of the evaluations and a brief discussion of the methodology. A complete description of the methodology used in the evaluations can be found in Appendix A.

7.1.2 Cumulative Measurement Error

Only certain of the specifications listed in the previous sections could be assigned error values. These specifications were evaluated at the pass/fail limit proposed by the State of Missouri, (20 percent failure rate), for each of two model-year groups for both HC and CO. The 20 percent failure rate has been specified to achieve the emission reductions called for in the Missouri SIP.

Each specification was assigned either a positive or negative error value. The cumulative signed error was then calculated for each set of specifications using an error propagation formula. These cumulative errors are shown in Table 7-1 and are expressed as a percentage of the specific emission value. It should be noted that these are estimates of measurement error at fixed concentrations. Also, as the emission levels decrease, the cumulative error increases.

As seen in the table, the ETI and BAR 74 specifications yield similar cumulative errors. Both sets of specifications have cumulative CO positive errors that are smaller than the negative CO errors and the cumulative HC positive errors are greater than the negative HC errors. The magnitude of the BAR 74 CO errors are smaller than those for ETI, and the BAR 74 HC errors are approximately equal to the ETI.

The BAR 80 and EPA cumulative errors are smaller in magnitude than both the ETI and BAR 74. Also, the cumulative positive errors are strictly less than the cumulative negative error for both pollutants.

7.1.3 Effect of Measurement Error on Pass/Fail Determination

An average error, without regard to sign, was calculated for each set of specifications shown in Table 7-1. Due to the similarties in the ETI and BAR 74 results, one average error was assumed to be representative of both. Using the data obtained from the Missouri pilot I/M program and standard probability theory, it was possible to calculate the number of vehicles that would incorrectly pass or fail during the proposed program. These totals were subdivided into two categories:

Category 1 - Vehicles that passed when they should have failed.
Category 2 - Vehicles that failed when they should have passed.

These results are shown in Table 7-2. It is evident from the data that relatively small changes in error have a great impact on the number of incorrect determinations.

TABLE 7-1. CUMULATIVE MEASUREMENT ERROR

Specification	Sign	Cumulative error, % of emission value			
		CO		HC	
		6%	4%	450 ppm	400 ppm
ETI	+	11.7	17.7	29.6	33.2
	-	16.2	21.5	25.6	28.5
BAR 74	+	9.2	11.2	30.0	33.8
	-	14.5	16.8	26.0	29.0
BAR 80	+	5.5	8.2	11.8	13.2
	-	11.5	13.0	14.0	15.0
EPA	+	6.0	6.0	6.9	7.2
	-	8.3	8.2	8.2	8.8

TABLE 7-2. SUMMARY OF RESULTS

Pollutant	Specification	Number of vehicles		
		Incorrectly passing Category 1	Incorrectly failing Category 2	Total incorrect
CO	EPA	658	827	1485
	BAR 80	2437	3085	5522
	ETI/BAR 74	6039	7814	13853
HC	EPA	787	320	1107
	BAR 80	5014	3509	8523
	ETI/BAR 74	14299	11745	26044

7.1.4 Change in Program Stringency

The number of vehicles that fall into Category 1 have the effect of lowering the actual I/M stringency. Using the data in Table 7-2 this effect was quantified for each set of specifications as demonstrated in Table 7-3. It is evident from these data that as the measurement error increases the effective program stringency decreases.

If any one of the analyzers were used in the planned program, the emission reductions specified in the SIP would not be achieved unless the program stringency were increased. However, as shown in Table 7-3, the increased stringency would probably be required only for HC and only if either a BAR 74 or ETI analyzer were used in the program.

7.2 OPERATOR ERROR

Many of the changes made between the BAR 74 and BAR 80 specifications relate to features intended to minimize analyzer operator error. Primary among these features are:

- Warmup lockout
- Integral gas spanning system
- Automatic electrical span
- Leak check capability
- 12-inch probe to eliminate sample dilution
- Self-draining water removal system
- Changes in instrument meter ranges to lessen errors in reading test values

The EPA unit has additional features to minimize operator error as compared to the BAR 80 features. These items were listed in Section 5.

Unlike the specifications evaluated in Section 7, these features to minimize operator error cannot be quantitatively evaluated since a probability term is required that would represent the likelihood of an operator improperly using an analyzer because of ignorance or neglect. If an operator using a BAR 74 unit were to use the analyzer properly, the BAR 80 features to minimize error would not produce an increase in accuracy. However, in a decentralized program, some operator error is inevitable. The potential magnitude of error from improper analyzer operation is equal to or greater than the quantifiable specification evaluations in Subsection 7.1.

In order to illustrate this point, one aspect of operator error, leak checking, was evaluated for its effect on the cumulative error. In the error analysis described in Appendix A, it

TABLE 7-3. EFFECT OF MEASUREMENT ERROR ON PROGRAM STRINGENCY

Pollutant	Specification	Error	Number of incorrectly passing vehicles	Actual stringency, %[a]
CO	EPA	7	658	19.9
	BAR 80	10	2437	19.8
	ETI/BAR 74	15	6039	19.5
HC	EPA	8	787	19.9
	BAR 80	14	5014	19.6
	ETI/BAR 74	29	14299	18.8

[a] Planned stringency is 20 percent.

was assumed that the error due to flow leaks would be no greater than 0.3 percent CO for both BAR 74 and ETI analyzers. At a 6 percent CO emission level, this value equates to a 5 percent leak. If all other individual errors were to remain constant and an additional 15 percent flow leak were to be introduced into the system, the resulting cumulative negative errors in Table 7-1 would increase by 9.0 percent for the ETI analyzers and 9.7 percent for the BAR 74 analyzers.

This conservative example demonstrates the potentially large effect that operator error can have on measured emission values. Consequently, it is important to establish appropriate quality assurance requirements for a decentralized program to minimize these errors. Alternatively, these requirements can be minimized by using more sophisticated analyzers such as the BAR 80 or EPA specification units that have features to reduce operator error.

7.3 CHANGE IN I/M PROGRAM COSTS RELATED TO EMISSION ANALYZER SELECTED

I/M program costs are borne by three groups: the state, the decentralized station owner, and the vehicle owner. Certain program costs are changed or redistributed depending on the emission analyzer selected. These items and their related cost estimates are presented briefly in this subsection. A full discussion of the calculation methodology is presented in Appendix B.

Significant changes in program cost have been identified in four major areas. Each of these areas is discussed below and the affected groups are identified.

7.3.1 Gas Calibration

If an automatic self-gas calibration specification is included in the analyzer requirements for the I/M program, then both the state and the decentralized station owner would realize a cost saving. During the first year, the state could reduce manpower costs for station audits by $59,400. The 1000 stations would each save $260 on the labor cost for weekly calibrations. Weekly calibration is the minimum frequency recommended by the EPA for decentralized programs. No unit is presently available with automatic gas calibration features. EPA estimates that this self-calibration feature could be included in a new production analyzer for around $150.

7.3.2 Data Processing

The state could achieve additional cost savings if the EPA option for automatic data collection was included in the analyzer requirements. By utilizing this option, the state would reduce data handling costs by approximately $16,950 the first year of the program.

There are two drawbacks to this option. First, no analyzer is presently available that contains this option. Second, the option would only be possible with a computerized analyzer.

7.3.3 Instrument Costs

The presently available analyzers were listed in Table 6-1. The range of analyzer costs was found to be as follows:

Specification	Range of costs
ETI/BAR 74	$2500-4170
BAR 80	$4995-6950

Based on the range of costs, each station would spend between $2500 and $7000 for its inspection analyzer, depending on the type of unit purchased.

7.3.4 Repair Costs

Varying levels of instrument measurement error were presented in Subsection 7.1. Based on the HC error for each set of specifications it was shown that the overall consumer costs decrease with increasing measurement error. However, program stringency and associated emission reduction also decrease. With a perfectly accurate analyzer, annual consumer repair costs were estimated to be $8.4 million. The estimated costs for each set of analyzer specifications was determined to be:

Specification	Annual reduction in consumer repair costs
ETI/BAR 74	$8,310,610
BAR 80	$8,347,325
EPA	$8,383,655

It should be reiterated that these are only estimated values and should only be used to compare the relative values for each analyzer. The analysis methodology used to arrive at these numbers included no estimate of additional measurement error due to the operator.

7.4 RECOMMENDED ANALYZER SPECIFICATIONS

It is recommended that the State of Missouri adopt the BAR 80, or some similar set of specifications, for their I/M program.

The rationale for this recommendation is based on a number of considerations. First, while the EPA specifications are more accurate than any of the others, there are no analyzers on the market that meet these specifications. Also, EPA may make changes in the specifications in the near future. Second, the BAR 80 specifications analyzers meet the 207(b) warranty requirements. These warranty benefits will be important to the motor vehicle owners as a means of lowering repair costs. The third consideration is the overall measurement accuracy of available analyzers. As shown in Table 7-3, the larger HC measurement error in the ETI/BAR 74 specifications yields a lower effective program stringency than is seen for the BAR 80 specifications. The final consideration is the BAR 80 analyzer features that protect against operator error. Operator errors are potentially greater than inherent analyzer errors, leading to larger measurement inaccuracies.

These four considerations--availability, 207(b) compatibility, accuracy, and protection against operator error, suggest that the BAR 80 specifications are the best choice for the Missouri I/M program.

APPENDIX A

ANALYZER SPECIFICATION EVALUATION

METHODOLOGY

Four sets of analyzer specifications were used to determine estimates in the following three areas:

1. The range of measurement error associated with each set of specifications.
2. The effect these errors could have on the number of cars passing or failing in the proposed I/M program.
3. The effect that the change in the pass/fail distribution of motor vehicles would have on the overall I/M program effectiveness in meeting air quality goals.

The evaluation methodology used for these three areas is discussed below. Included in the discussions are the assumptions and mathematical procedures required to perform the evaluation.

ESTIMATION OF MEASUREMENT ERROR

Each of the analyzer specifications was evaluated to determine its effect on in-use measurement accuracy. The end result was to calculate the cumulative measurement error, assuming that the analyzers would not exceed the specification values stated by the manufacturer. The error analysis was based totally on the published analyzer specifications and it was assumed that the analyzer operator would maintain the analyzer within the specifications. In other words, the calculated errors reflect only those errors inherent to the specifications and do not include any additional error due to improper operation and maintenance. This additonal error is potentially larger than that inherent to the specifications.

Some of the specifications are not expressed as percent CO or ppm HC but rather as percent of scale or point. Consequently, each specification was evaluated at specific pollutant levels. These values were determined from data obtained during Missouri's pilot I/M program.

The data that were obtained included the distribution of measured emission levels by vehicle model year. To simplify the analysis, the data for individual model years were combined into two model year groups--1969-1974 vehicles and 1975 and newer vehicles. The resulting distributions are shown in Tables A-1 and A-2. These groups are almost identical to those associated with the voluntary emission standards used in the pilot program.

Each specification was evaluated at the approximate 80 percentile emission value determined from the distributions in Table A-1 and A-2. These values are shown below:

	80 percentile value	
	CO	HC
1969-1974 vehicles	6 percent	450 ppm
1975 and newer	4 percent	400 ppm

The 80 percentile level was chosen, since Missouri has specified a 20 percent stringency level for its I/M program. Also, the error associated with very large or very small emission values is of lesser importance in the determination of whether a vehicle passes or fails the I/M test. Consequently, analyzer errors were calculated only for the pass/fail emission values.

Each individual specification has a resultant measurement error. However, only certain of these errors can be quantified. The magnitude of the error is directly related to the stringency of the specification. For some specifications there is an equal chance that the measurement error will be positive or negative (i.e., random error). For others, the measurement error will be definitely of one sign or the other. Certain specifications are interrelated and the total error is contained within one specification.

Each of the analyzer specifications shown in Sections 2 and 3 were evaluated for resultant measurement error. These are briefly discussed below. Included in the discussion are the assumptions used and an indication of the sign of the error. Specifications in Section 4 (construction materials and dependability) and Section 5 (decentralized program recommendations) were not included in the error analysis. They were excluded to limit the analysis to accuracy specifications only, as opposed to dependability or operation error (see Subsection 7.2 for an explanation of problems associated with analyzing operator error).

Table A-3 lists the specifications for which a related measurement error could be determined. Also included in the table is the indication of the sign of the error and the magnitude of the error at the given idle emission levels.

TABLE A-1. DISTRIBUTION OF MEASURED CO VALUES

Range, % CO	1969-1974 vehicles			1975 and newer vehicles		
	Frequency	Cumulative frequency	Cumulative percent	Frequency	Cumulative frequency	Cumulative percent
0- 0.5	106	106	12.0	1052	1052	47.4
0.51- 1.0	67	173	19.6	155	1207	54.8
1.01- 1.5	42	215	24.4	106	1313	59.6
1.51- 2.0	53	268	30.4	92	1405	63.7
2.01- 2.5	45	313	35.5	106	1511	68.6
2.51- 3.0	64	377	42.8	98	1609	73.0
3.01- 3.5	52	429	48.7	65	1674	76.0
3.51- 4.0	57	486	55.2	92	1766	80.1
4.01- 4.5	42	528	59.9	72	1838	83.4
4.51- 5.0	71	599	68.0	70	1908	86.6
5.01- 5.5	38	637	72.3	50	1958	88.8
5.51- 6.0	56	693	78.7	63	2021	91.7
6.01- 6.5	33	726	82.4	47	2068	93.8
6.51- 7.0	31	757	85.9	31	2099	95.2
7.01- 7.5	24	781	88.6	22	2121	96.2
7.51- 8.0	31	812	92.2	26	2147	97.4
8.01- 8.5	14	826	93.8	16	2163	98.1
8.51- 9.0	27	853	96.8	19	2182	99.0
9.01- 9.5	7	860	97.6	13	2195	99.6
9.51-10.0	21	881	100.0	9	2204	100.0

TABLE A-2. DISTRIBUTION OF MEASURED HC VALUES

Range, % HC	1969-1974 vehicles			1975 and newer vehicles		
	Frequency	Cumulative frequency	Cumulative percent	Frequency	Cumulative frequency	Cumulative percent
0- 49	16	16	1.8	307	307	13.9
50- 99	105	121	13.7	438	745	33.8
100- 149	141	262	29.7	266	1011	45.9
150- 199	152	414	46.9	215	1226	55.6
200- 249	90	504	57.2	192	1418	64.3
250- 299	64	568	64.5	141	1559	70.7
300- 349	62	630	71.5	124	1683	76.4
350- 399	46	676	76.7	83	1766	80.1
400- 449	31	707	80.2	88	1854	84.1
450- 499	25	732	83.1	60	1914	86.8
500- 549	21	753	85.5	57	1971	89.4
550- 599	9	762	86.5	28	1999	90.7
600- 649	8	770	87.4	32	2031	92.2
650- 699	6	776	88.1	24	2055	93.2
700- 749	17	793	90.0	17	2072	94.0
750- 799	4	797	90.5	11	2083	94.5
800- 849	11	808	91.7	17	2100	95.3
850- 899	5	813	92.3	14	2114	95.9
900- 949	8	821	93.2	16	2130	96.6
950- 999	2	823	93.4	4	2134	96.8
1000-1049	8	831	94.3	15	2149	97.5
1050-1099	0	831	94.3	2	2151	97.6
1100-1149	7	838	95.1	11	2162	98.1
1150-1199	1	839	95.2	5	2167	98.3
1200-1249	7	846	96.0	5	2172	98.5
1250-1299	0	846	96.0	1	2173	98.6
1300-1349	0	846	96.0	3	2176	98.7
1350-1399	1	847	96.1	0	2176	98.7
1400-1449	1	848	96.3	6	2182	99.0
1450-1499	0	848	96.3	1	2183	99.0
1500-1549	3	851	96.6	2	2185	99.1
1550-1599	1	852	96.7	0	2185	99.1
1600-1649	4	856	97.2	2	2187	99.2
1650-1699	1	857	97.3	2	2189	99.3
1700-1749	0	857	97.3	2	2191	99.4
1750-1700	1	858	97.4	2	2193	99.5
1800-1849	2	860	97.7	0	2193	99.5
1850-1899	0	860	97.7	0	2193	99.5
1900-1949	0	860	97.7	0	2193	99.5
1950-1999	0	860	97.7	0	2193	99.5
2000-2050	21	881	100.0	11	2204	100.0

TABLE A-3. MEASUREMENT ERROR OF ANALYZER SPECIFICATIONS

Specification	Sign	ETI				BAR 74				BAR 80				EPA			
		% CO		ppm HC		% CO		ppm HC		% CO		ppm HC		% CO		ppm HC	
		6	4	450	400	6	4	450	400	6	4	450	400	6	4	450	400
Calibration accuracy	±	0.6	0.6	50	50	0.3	0.15	30	30	0.3	0.15	30	30	0.3	0.2	22.5	20
Zero drift	±	0.03	0.03	7.5	7.5	0.15	0.075	15	15	0.03	0.03	6	6	0.02	0.02	4	4
Span drift	±	0.14	0.14	27	27	0.15	0.075	15	15	0.03	0.03	6	6	0.02	0.02	4	4
HC hangup	+			100	100			100	100			30	30			10	10
Interference-gas (3)	±	0.05	0.05	10	10	0.1	0.1	20	20	0.05	0.05	10	10	0.02	0.02	4	4
Interference-electrical (5)	±	0.05	0.05	10	10	0.1	0.1	20	20	0.05	0.05	10	10	0.02	0.02	4	4
Leaks	-	0.3	0.3	60	60	0.3	0.3	60	60	0.05	0.05	10	10	0.18	0.12	13.5	12
Low flow	±	0.3	0.3	60	60	0.3	0.3	60	60	0.05	0.05	10	10	0.18	0.12	13.5	12
Response time	-	0.6	0.4	45	40	0.6	0.4	45	40	0.6	0.4	45	40	0.3	0.2	22.5	20
Cumulative error	+ -	0.70 0.97	0.70 0.86	133 115	133 114	0.55 0.87	0.45 0.67	135 117	135 116	0.33 0.69	0.33 0.52	53 63	53 60	0.36 0.50	0.24 0.33	31 37	29 35
Percent of emission value	+ -	11.7 16.2	17.5 21.5	29.6 25.6	33.2 28.5	9.2 14.5	11.2 16.8	30.0 26.0	33.8 29.0	5.5 11.5	8.2 13.0	11.8 14.0	13.2 15.0	6.0 8.3	6.0 8.2	6.9 8.2	7.2 8.8

Analyzer Calibration Accuracy--Subsection 2.1

The maximum error was assumed to be the calibration limits measured at 50°F and 85 percent humidity. A positive or negative error is equally likely.

Zero and Span Drift--Subsection 2.2

It was assumed that a maximum of 1/2 of the zero and span values would be present at the specific pollutant levels. Errors could be positive or negative.

HC Hangup--Subsection 2.3

One-half of the allowable HC hangup values was used as the maximum value that would be encountered in actual use. Error is definitely positive.

Interferences--Subsection 2.4

Errors are specified for each gaseous interference. However, EPA recommendations include only three interferents. Therefore, only three individual error values were included. No specifications were included in the ETI and BAR 74 specifications for electrical interferences. For the BAR 80 and EPA analyzers the allowable error values were used, but only for the five items required under BAR 80. ETI and BAR 74 error levels, for the same five items, were conservatively assumed to be equal to the gaseous specifications. Errors for both gaseous and electrical interferences could be positive or negative.

Leaks--Subsection 2.5

The EPA specifications were the only one of the four that included leak checks. This is a potentially large source of error. Negative errors due to leaks were conservatively estimated to be the value which triggers the low flow indicator.

Repeatability--Subsection 2.6

These specifications are directly related to analyzer calibration accuracy. No additional error is expected due to these specifications.

Temperature, Humidity Operating Range--Subsection 3.1

Included in assumptions for calibration accuracy.

Warmup Time and Lockout--Subsection 3.2

It was assumed that the analyzers would be operated only after recommended warmup time.

Probe Design, Sample Line Design, Water Removal System, Conversion Factor--Subsection 3.3-3.6

No errors can be assigned to these specifications when analyzers are operated according to manufacturer's recommendations.

Low Flow Indicator--Subsection 3.7

Maximum error was assumed to be low flow indicator critical value. Error could be positive or negative.

Meter Design--Subsection 3.8

Meter design is only critical for analog meters. The scale divisions determine the potential error. The measurement error was assumed to be one-half of the scale interval for the lowest scale capable of reading the specified emission levels. Error could be positive or negative.

Instrument Range--Subsection 3.9

Instrument range has been taken into consideration for several other specifications.

Response Time--Subsection 3.10

The maximum error associated with the specification was assumed to be 100 minus specified percent of final reading. Error is definitely negative.

Cumulative errors were calculated from the specifications shown in Table A-3. Both cumulative positive and cumulative negatives errors were calculated using the following equation:

$$E_c = E_1^2 + E_2^2 \ldots + E_n^2 \qquad \text{(Eq. 1)}$$

where E_c = cumulative error (positive or negative)

$E_1 E_n$ = individual error components

The resulting values are shown in Table A-3. As seen in the table, the ETI and BAR 74 specifications yield similar cumulative errors. Both sets of specifications have cumulative CO positive errors that are smaller than the negative errors and cumulative HC positive errors that are greater than the negative errors.

The magnitude of the BAR 74 CO errors are smaller than those for ETI, but the BAR 74 HC errors are almost identical to the ETI. The BAR 80 errors are smaller than the ETI/BAR 74 and the EPA errors are even lower.

EFFECT OF MEASUREMENT ERROR ON PASS/FAIL DETERMINATION

In order to determine the effect of cumulative measurement error on the number of cars that pass or fail the idle test, it was necessary to make a number of simplifying assumptions. These assumptions were necessary so that standard probability relationships could be used. These assumptions are discussed below.

Assumption 1

The measurement errors are normally distributed. As seen in Table A-3, the errors actually have a positive or negative bias depending on the pollutant. However, the use of probability relationships requires that the error around a given measured value have an equal likelihood of being positive or negative.

Assumption 2

The average percent cumulative error positive or negative for a specific pollutant yields a reasonable estimate of a three standard deviation (3σ) error about the measured emission value. As shown in Table A-3, the cumulative error varies with the magnitude of the emission value. In addition, these are estimates of the measurement error at fixed emisson levels. In order to use a probability function the error must be expressed in terms of the standard deviation. Also, expressing the error as a percent of the measured value, approximates the results shown in Table A-3.

Assumption 3

The vehicle distributions determined from the Missouri pilot program are an unbiased sample of the vehicle population. This was the most critical assumption, since there exists some level of measurement error in the sample data. However, it was impossible to isolate the measurement error inherent to the data. In order to make any inferences about the effect of measurement error, it had to be assumed that the data were obtained with a perfect (no error) analyzer.

Assumption 4

The average combined error (percent), for the ETI and BAR 74 specifications was a reasonable estimate for the error in both systems.

Given the above assumptions, it was then possible to calculate the numbers of vehicles that fell into the following two categories:

Category 1 - Vehicles that passed when they should have failed (pass-fail)
Category 2 - Vehicles that failed when they should have passed (fail-pass)

The number of vehicles in these categories was determined for three different error levels for each pollutant. These were:

	Percent error		
	BAR 74/ETI	BAR 80	EPA
CO	15	10	7
HC	29	14	8

The error analysis was performed for three error levels for each of two pollutants (CO and HC) based on vehicle distributions for two model year groups (1969-1974, 1975 and newer). The calculation procedures were focused on the pass/fail value for each pollutant and model-year group. For vehicles whose true emission value is greater than the limit, only negative errors will affect the pass/fail distribution, i.e., vehicles that passed when they should have failed. The number of vehicles in this category can be determined from the left-tailed probability of the standard normal distribution. Conversely, the right-tailed probability can be used to determine the number of vehicles that fail when they should have passed. The basic calculation steps are outlined below. An illustrative example is shown in Table A-4.

Step 1. Determine the midpoint value for each emission level range for each pollutant.

Step 2. Identify fail point (20 percent stringency) for each model year group and each pollutant within that group.

Step 3. Choose 3 σ error for evalution--percent.

Step 4. Calculate 1 σ error--3σ error ÷3.

Step 5. Calculate the standard deviation (s.d.) about each midpoint value--s.d. = midpoint x % error.

Step 6. Calculate the right- or left-tailed probability value (z) that with a given error, a vehicle, whose true emission value is in the specified range, will fall into Category 1 (pass-fail) or 2 (fail-pass). Repeat for each interval.

$$z = \frac{\text{fail point - midpoint}}{\text{s.d.}}$$

TABLE A-4. EXAMPLE CALCULATION

Pollutant: CO

Emission level: 5.51 - 6.0%

Midpoint: 5.755 Fail point: 6%

Error (3σ): 15% Error (1σ): 5%

One standard deviation about midpoint: 5.755 x 0.05 = 0.2878

$$z = \frac{6.0 - 5.755}{0.2878} = 0.85$$

Tabled right-tail probability: 1-0.8223 = 0.1977

Sample population: 3,085 vehicles

Sample frequency of vehicles in 5.51-6.0% CO range = 56

Fraction of sample population: $\frac{56}{3085} = 0.0182$

Number of fail-pass vehicles: $0.0182 \times 0.1977 \times 1.2 \times 10^6 = 4318$

Based on the 15 % error 4.318 vehicles will fail the idle test when they should have passed.

Step 7. Look up the standard normal probability for calculated z values in a statistic table.

Step 8. Record right (+z) or left (-z) tailed probability for each value.

-z = table value

+z = 1- table value

Step 9. Calculate fraction of total sample population contained in each emission level range. Fraction = $\frac{\text{frequency}}{\text{total sample size}}$.

Step 10. Calculate the number of vehicles that fall into fail-pass or pass-fail category for each interval, based on an estimated population of 1.2 million vehicles in proposed I/M program--Number = fraction x probability x 1.2×10^6.

Step 11. Sum the number of pass-fail and fail-pass vehicles and total for each pollutant.

The overall results of the calcuations are shown in Table A-5. The numbers shown in the table demonstrate the relative effect of measurement error for the proposed I/M program. It is evident that as the measurement error increases, the number of incorrect pass/fail determinations escalates rapidly. The effect that this has on the overall I/M program is evaluated in the next Subsection.

Effect of Improper Pass/Fail Determination on Overall I/M Program

There are different consequences resulting from an improper pass/fail determination depending on the category that is considered. For Category 2 vehicles, those that failed when they should have passed, the consumers are affected in two ways. Those consumers are out both the time and money involved in needless repairs on the vehicles as well as the time required for a retest. The I/M program is also affected. Little or no emission reduction will be realized by repairing these vehicles.

For Category 1 vehicles, those that pass when they should fail, there are other consumer and program effects. These consumers do not have the required repair or maintenance performed. Consequently, the consumers do not realize potential fuel economy savings and maintenance costs may be higher in the long run. These vehicles have a significant effect on the I/M program. The number of vehicles in this category actually reduce the program stringency and the needed emission reductions are not realized.

TABLE A-5. SUMMARY OF RESULTS

Pollutant	Specification	3σ error	Number of vehicles		
			Incorrectly passing Category 1	Incorrectly failing Category 2	Total incorrect
CO	EPA	7	658	827	1485
	BAR 80	10	2437	3085	5522
	ETI/BAR 74	15	6039	7814	13853
HC	EPA	8	787	320	1107
	BAR 80	14	5014	3509	8523
	ETI/BAR 74	29	14299	11745	26044

It is possible to calculate the effect on the program stringency from these results. If it is assumed that the Category 2 vehicles will achieve an insignificant emission reduction, since they are already clean; then, only the number of Category 1 vehicles will affect the program stringency. These vehicles should achieve an emission reduction with a perfect measurement system, but do not when error is introduced into the measurement.

Based on a population of 1.2 million vehicles, a 20 percent program stringency is designed to fail 240,000 vehicles. The actual program stringency with a given measurement error can be calculated as follows:

Actual stringency = (240,000 - number of Category 1 vehicles)/ 1.2×10^6

This calculation was performed on the data shown in Table A-5 with the following results:

Pollutant	Error	Specification	Number of Category 1 vehicles	Actual stringency
CO	7	EPA	658	19.9
	10	BAR 80	2437	19.8
	15	ETI/BAR 74	6039	19.5
HC	8	EPA	787	19.9
	14	BAR 80	5014	19.6
	29	ETI/BAR 74	14299	18.8

From the above, it is evident that the HC errors have a greater impact than do the CO errors. First of all, the magnitude of the HC errors is greater than the associated CO error for each set of specifications. Also, the distribution of measured HC data, as shown in Table A-2, is skewed more towards low HC readings than was seen in the CO data. In order to achieve an actual 20 percent stringency the pass/fail cut point would have to be lowered to fail more of the population. The magnitude of this adjustment would depend on which set of specifications were selected.

APPENDIX B

CHANGE IN I/M PROGRAM COSTS RELATED TO EMISSION ANALYZER SELECTED

INTRODUCTION

The purpose of this appendix is to describe the framework for evaluation of I/M program costs related to the emission analyzer selected. I/M program costs are borne by three groups, i.e., the state, the decentralized station owner, and the vehicle owner.

COST CHANGES TO THE STATE

Cost changes to the state varying with emission analyzer selection are shown in Table B-1. Most costs have no relationship to the emissions analyzer. The five cost items that will change with analyzer selection are related to two factors. These factors are program audit functions, and data processing.

Gas Calibration

The EPA has specified that a gas calibration audit be performed on all analyzers at least monthly in a decentralized program. The only waiver from this EPA mandate is if computer controlled emission analyzers with self-gas calibration features are used. Then, gas calibration audits by state personnel need only be performed quarterly. Only the EPA specifications (decentralized program) require a computerized self-gas calibration and would qualify as only requiring quarterly surveillance.

The need for state personnel to perform gas calibrations only one-third as often, when using computerized self-calibrating analyzers, impacts four of the five state costs varying by the type of emission analyzer. The total number of examiners required for program surveillance would be only one-third of the level required for monthly gas calibrations. This would decrease costs of hiring and training examiners, audit related equipment, examiner wages, and surveillance costs (travel and expendables).

The Missouri Highway Patrol has estimated the need for an additional eight motor vehicle inspectors of which seven would be

TABLE B-1. CHANGE IN I/M PROGRAM COST RELATED TO EMISSION ANALYZER SELECTED-STATE COSTS

	Cost does not vary with analyzer selected	Cost does vary with analyzer selected
A. Start-up costs		
1. Administrative		
Wages	●	
Hiring and training examiners		●
Initial public information	●	
Initial program design	●	
Mechanic training (if state sponsored)	●	
Office equipment	●	
Audit related equipment		●
2. State challenge lanes		
Land acquisition	●	
Building	●	
Hiring and training personnel	●	
Office supplies	●	
B. Recurring costs		
1. Administrative		
Wages (direct and overhead)		●
Surveillance costs (travel, expendables)		●
Public information	●	
Computer processing		●
Office equipment	●	
2. State challenge lanes		
Amortized capitol cost	●	
Wages (direct and overhead)	●	
Equipment maintenance	●	

involved in the audit function at any one time (Missouri Air Conservation Commission 1980). Self-calibration would allow the number to be decreased to three at an annual savings to the state of $59,433 in the first year or $348,670 over five years, assuming 8 percent wage inflation each year. This cost would be transferred to the station owner in the form of additional analyzer cost, but the station will also have decreased labor costs. However, no gas self-calibrating analyzer is commercially available at this time. The subject is evaluated in greater depth in another report (PEDCo Environmental 1981a).

DATA PROCESSING

The only other analyzer specification that would impact I/M costs for the state is the EPA option for automative data collection. With this option (see Subsection 7.1), data is stored on a magnetic cassette tape or other storage medium in a tamper proof container with an antitampering seal. The state examiner retrieves the cassette tape while at the station doing other audit functions. The state can then machine read the data. This system contrasts to the more usual situation wherein the station inspector fills out a form, the forms are collected by the state examiner, and later keypunched to cards or tape for analysis. With the automatic data collection system, no manual data entry is required by state personnel.

The Missouri Highway Patrol has estimated that two clerks would be required for data inventory at an annual cost of $22,595. Assuming 1.5 less clerks would be required, the cost savings to the state over five years would be $99,419 (at 8 percent wage inflation each year). These cost savings would be transferred to station owners in increased analyzer cost but decreased labor cost for record keeping. This subject is treated in greater depth in another report (PEDCo Environmental 1981b).

COST CHANGES TO DECENTRALIZED STATION OWNERS

Cost changes to the decentralized station owner vary with emission analyzer selection are shown in Table B-2. Four cost items vary with the analyzer selected, all related to analyzer specifications.

Analyzer Cost--Basic Units

The first item is analyzer cost. Analyzer costs are shown in previously cited Table 6-1.

TABLE B-2. CHANGE IN I/M PROGRAM COST RELATED TO EMISSION ANALYZER SELECTED-DECENTRALIZED STATION COST

	Cost does not vary with analyzer selected	Cost does vary with analyzer selected
A. Start-up costs		
Analyzer and related equipment		●
Manuals and required equipment	●	
Mechanic training	●	
B. Recurring costs		
Equipment repair	●	
Calibration gas and expendables	●	
Mechanic wages (direct and overhead)		
Testing	●	
Recordkeeping		●
Calibration		●

Analyzer Costs--Optional Features

Beyond the cost of the analyzer, reoccurring costs vary with the analyzer specified. These are labor costs associated with recordkeeping and gas calibration. With the automatic data collection system, time required to record the test results and store the forms would not be required. However, since the I/M program is projected to be combined with the vehicle safety inspection which requires filling out a form, cost savings would be minimal if the recordkeeping from both programs were combined into the automatic data collection system. Savings in labor cost in any event would probably be relatively slight amounting to about two to four minutes per test over the long run. In the short run, confusion about the automatic data collection keyboard would probably obliterate any cost savings.

Some programs require that station operators gas calibrate their analyzers weekly. Other programs do not require any gas calibration by the station operator relying on the monthly state gas calibration only. Self-gas calibrating units also eliminate the need for station operator calibration. When gas calibrations are required, the procedure would require no more than 15 minutes weekly. Over a 5 year program, labor time would be less than 65 hours per station. As an average of $20 per hour, increasing at 8 percent per year, costs per station over the five year period would be $1525.

The automatic gas calibration feature for an emissions analyzer is not commercially available. Units are under development. EPA (EPA 1980) estimates the cost of this feature to be $150 per analyzer. However, it is likely that it would not be available without the other features recommended by the EPA specifications for decentralized programs. The EPA analyzers are estimated to cost $6820, about $2470 more than a BAR 80 and $3445 more than a BAR 74 unit (EPA 1980).

Using a simplistic analysis, assuming a five-year analyzer life and 1000 inspection stations with analyzers, and salary increases of 8 percent per year, cost savings to the state would be $348,670. The increased cost of the analyzer to the stations (assuming the total EPA specification analyzer) would be $2,470,000 over a BAR 80 unit and $3,445,000 over a BAR 74 unit. If it is assumed that only the self-gas calibration option could be obtained for $150 per unit (this is unlikely), the added analyzer cost would be $150,000. To this analysis must be added the economic costs to the consumer relating to analyzer accuracy. These costs are described below.

COST CHANGES TO THE VEHICLE OPERATOR

Costs to the vehicle operator from an I/M program are the cost of the inspection and cost of repairs. Time costs are also involved but not considered, since they are not a direct cash outlay.

Inspection Cost

The inspection cost increase to vehicle owners is currently estimated to be $3.50 over the cost of the present safety inspection. The type of analyzer would influence the inspection fee insofar as analyzer costs change inspection costs per car for the station.

Repair cost

The repair cost to the consumer will vary depending on the analyzer selected. As seen in Appendix A the number of incorrect pass/fail determinatons increases with a decrease in analyzer accuracy. Since the program stringency also decreases with decreasing accuracy, the overall repair cost to the consumers also decreases. This seeming contradition is due to the fact that fewer cars are failed with an instrument of lower accuracy.

There is related cost increase to the consumer when a low accuracy instrument is used. Those vehicles that are failed incorrectly will require unneeded repairs.

The difference between these two cost items represents the overall reduction in repair cost to the consumer. Using the HC data generated in Appendix A, the example in Table B-3 demonstrates these points. The cost data are based on an average repair cost of $35/vehicle. (Missouri Air Conservation Commission, 1980).

One other aspect of the results shown in Table B-3 should be noted. First, the overall cost reductions represent repair dollars that will not be spent. At least a portion of these monies would represent lost profits for the decentralized stations.

TABLE B-3. CHANGE IN I/M PROGRAM COST RELATED TO EMISSION ANALYZER SELECTED-CONSUMER COSTS FOR REPAIRS

Specification	HC error, %	Number of incorrectly passing vehicles	Repair cost reduction, $	Number of incorrectly failing vehicles	Repair cost increase, $	Overall cost reduction, $
EPA	8	787	27,545	320	11,200	16,345
BAR 80	14	3014	175,490	3509	122,815	52,675
ETI/BAR 74	29	14299	500,465	11745	411,075	89,390

REFERENCES

Missouri Air Conservation Commission. 1980. Proposed Inspection Maintenance Program for Missouri.

U.S. Environmental Protection Agency. 1980. Analysis of the Emission Inspection Analyzer. EPA-AA-IMS-80-5-A.

PEDCo Environmental, Inc. 1981a. Support Document for Development of the Missouri Inspection/Maintenance Program--Quality Assurance Procedures.

PEDCo Environmental, Inc. 1981b. Support Document for Development of the Missouri Inspection/Maintenance Program--System Considerations.

QUALITY ASSURANCE PROCEDURES

CONTENTS

Page

Tables iii

1.0 Introduction 1
  1.1 Purpose 1
  1.2 Environmental Protection Agency requirements 1
  1.3 Report organization 3
  References 4

2.0 Elements of a Quality Assurance Program 5
  2.1 Analyzer related 5
  2.2 Ongoing audit functions 12
  References 15

3.0 Findings 16
  3.1 Recommended quality assurance program elements 16
  3.2 State personnel and equipment costs 16
  References 20

Appendices

A Overview of Quality Assurance Procedures for Existing I/M Programs 21
B California Certified Gas Blender Specifications 27
C Sample State Inspection Report Forms from Nevada and California 45

TABLES

Number		Page
2-1	Possible Elements in a Quality Assurance Program	6
3-1	Recommended Elements of a Quality Assurance Program	17
3-2	Estimated First Year Cost of Quality Assurance Procedures to the State	18

SECTION 1.0

INTRODUCTION

1.1 PURPOSE

The purpose of this report is to provide technical information to the State of Missouri on the range of quality assurance (QA) procedures available for use in a mandatory decentralized inspection/maintenance (I/M) program. This report will serve as the technical basis for the state in adopting regulations for quality assurance procedures.

The principal objectives of a quality assurance program in a decentralized I/M program are:

- To check the condition and accuracy of emissions testing equipment in the participating repair facilities.
- To assure that factual test results are reported on all vehicle emission levels.

1.2 ENVIRONMENTAL PROTECTION AGENCY (EPA) REQUIREMENTS

Most of the Environmental Protection Agency's requirements for an I/M program are contained in a 1978 EPA policy memorandum (Hawkins 1978). Requirements relating to quality assurance for the governing agency are that they:

- Provide for quality control regulations and procedures for the inspection system including required calibrations of all types and minimum recordkeeping.
- Maintain records on the calibration of testing equipment.
- Inspect each facility to check facility records, check the calibration of the testing equipment, and observe that proper test procedures are followed.
- Conduct an effective program of unannounced/unscheduled inspections both as a routine measure and as a complaint investigation measure.

- Operate a referee station where vehicle owners may obtain a valid test to compare to a test from a licensed station.

In a separate action, EPA has also suggested a 30 day minimum frequency for gas calibration by the governing agency. EPA is preparing guidance on gas naming but it is not available at this time.

Section 207 of the Clean Air Act also contains elements that relate to quality assurance. Section 207(b) is a consumer protection measure that requires vehicle manufacturers to warrant that a 1981 or later vehicle will conform to emission standards throughout its useful life providing that the vehicle is properly maintained and operated. For 5 years, all emission control devices must be warranted including the catalyst, air pump, and electronic controls. For the first 2 years/24,000 miles, parts of the ignition system (spark plugs, ignition wires, and similar components) are also covered. For Missouri consumers to take advantage of 207(b) warranty benefits, the Missouri program must meet 207(b) program specifications. Quality assurance related procedures included in Section 207(b) are:

- "Equipment shall be calibrated in accordance with the manufacturers instructions."
- "Within one hour prior to a test, the analyzers shall be zeroed and spanned... An electrical span check is acceptable."
- "The analyzers shall have been spanned and adjusted if necessary, using gas traceable to NBS [National Bureau of Standards] ±2 percent within one week of the test."
- "For analyzers with a separate calibration or span port, CO readings using calibration gas through the probe and through the calibration port shall be made (Federal Register 1980)."

The EPA's recommended specifications for inspection analyzers (EPA 1980) also contain recommendations (not requirements) from which certain quality assurance procedures can be inferred. EPA recommends that each state implementing a decentralized I/M program adopt the EPA specification for a computer operated analyzer. A computer operated analyzer automatically performs several quality assurance functions at preset intervals. If the analyzer fails the check, it becomes inoperable. The quality assurance checks include an electrical zero/span check (hourly), a gas calibration (4 hours recommended, weekly minimum), leak check (weekly), and an HC hangup check (before each test). Because of the instruments self-calibration procedure, EPA requires only quarterly state audits with this type of analyzer as compared to the required monthly audits. No unit meeting these recommendations is commercially available.

1.3 REPORT ORGANIZATION

Section 2 contains a description of the range of activities that can be incorporated into a quality assurance program and these activities are evaluated for the Missouri I/M program. Findings are presented in Section 3.

REFERENCES

Federal Register. May 22, 1980. Rules and Regulations. Section 85.2217, Vol. 45, No. 101.

Hawkins, D.G. July 17, 1978. Memorandum to EPA Regional Administrators. Washington, D.C.

U.S. Environmental Protection Agency. September 1980. Recommended Specifications for Emission Inspection Analyzers. EPA-AA-IMS-80-5-B.

SECTION 2.0

ELEMENTS OF A QUALITY ASSURANCE PROGRAM

Quality assurance procedures are necessary at both the decentralized testing location and the state audit levels. Possible elements are included in Table 2-1. Most quality assurance procedures are performed regularly by the decentralized station operator and audited less frequently by state personnel. The following subsections describe the range of activities possible for each major quality assurance element.

2.1 ANALYZER RELATED

2.1.1 Electrical Zero/Span

2.1.1.1 Overview--

An electrical zero and span check is a calibration function to assure analyzer accuracy. The only regulations applying to this procedure are Section 207(b) requirements that stipulate that the analyzer be zero/spanned checked within one hour prior to each test. On most manually operated analyzers, the operator need only press a button to instigate the check. If the analyzer fails the check, the operator must remove it from service. On computer operated analyzers, the check is made automatically each hour and if the analyzer fails the check it becomes inoperative.

Examination of existing programs (Arizona, California, Cincinnati, Nevada, New Jersey, Oregon, and Rhode Island) indicates an electrical zero/span check by the operator ranging in frequency from twice per day, to hourly, to before each test.

2.1.1.2 Evaluation--

To meet Section 207(b) requirements and EPA recommended procedures, an electrical zero/span must be completed within one hour prior to each test. Because of this frequency, the procedure must be performed by the analyzer operator. Since the procedure is quick and easy to perform without error, this would be no hardship.

Many decentralized stations will not be inspecting cars every hour. Therefore, it is recommended that Missouri adopt regulations requiring an electrical zero/span check immediately

90

TABLE 2-1. POSSIBLE ELEMENTS IN A QUALITY ASSURANCE PROGRAM

Element	Performed by decentralized station operator	Performed or checked by state personnel
Analyzer related		
Electrical zero/span	●	●
Gas calibration	●	●
Leak check	●	●
HC hangup check	●	●
Gas naming	●	●
Internal log	●	●
Ongoing audit functions		
Data audit		●
Undercover vehicles		●
Citizen complaint investigations		●
Challenge stations		●

prior to each test by the analyzer operator. This regulation would meet 207(b) requirements and eliminate the need to zero/span check the machine during the hours when it was not in use. If the analyzer does not pass the check, it should be taken out of service by the operator. The state auditor should perform a zero/span check immediately prior to the gas calibration audit.

2.1.2 Gas Calibration

2.1.2.1 Overview--

In a gas calibration procedure, gas of a known concentration is drawn into the emissions analyzer to check analyzer accuracy. The concentration indicated by the analyzer must be within a specified interval of the known concentration. Regulations applying to this function are the EPA policy requiring monthly gas calibration, and Section 207(b) requirements that stipulate weekly gas calibration. On ETI and BAR 74 specification analyzers, the operator must connect hoses to the analyzer and to the span gas or draw span gas through the probe. On BAR 80 and EPA specification analyzers, no connections are required; only a button must be pressed. On EPA specification analyzers, the interval is automatically set for every power on and every four hours of testing.

Examination of gas calibration practices for existing programs show a wide range of participation and frequency. With centralized programs, the frequency varies from five times per day by the lead inspector (Oregon) to weekly by garage personnel (California). In some of the centralized programs, span gases at several concentrations are used to check calibration over a range of expected levels. In decentralized programs, a state audit is performed once a month in most programs. The major difference is whether the operator must perform gas calibrations or not. In Nevada, for example, no gas calibrations by the operator are required, meaning that the analyzer is gas calibrated only once a month.

2.1.2.2 Evaluation--

To meet Section 207(b) requirements, weekly gas calibrations are required. As a practical matter, it is recommended that the gas calibrations be performed by the operator as opposed to state personnel. To conform with EPA policy, a monthly state audit is required.

The EPA recommendation that gas calibrations be performed every 4 hours would add considerable expense for the station operator for both labor (15 to 45 minutes/day) and for calibration gas. Also, many stations may not even perform inspections as often as every 4 hours. No quantifiable data have been presented by EPA that support a significantly greater level of analyzer accuracy with 4 hour calibrations as opposed to weekly calibrations. Therefore, it is recommended that Missouri adopt regulations requiring weekly gas calibrations by the decentralized station operator and monthly gas calibrations by state personnel.

2.1.3 Leak Checks

2.1.3.1 Overview--

A leak check is a procedure where the negative pressure portions of the analyzer are checked for air leaks which would allow an excess of ambient air into the sample gas and therefore result in a lower concentration reading. The only regulations applying to the procedure are Section 207(b) requirements that stipulate weekly leak checks. The leak check is to be made by comparing test results from a calibration gas drawn through the probe to calibration gas through the calibration port; discrepancies of over 3 percent require repair of leaks.

All analyzers have the capability to be leak checked in the 207(b) stipulated manner although leak checks have seldom been performed in this manner. On BAR 74 analyzers used in the California program, the leak check was actually part of the accuracy check. Calibration gas was drawn through the probe and if the machine was not within accuracy specifications, the analyzer was checked for leaks as one of the possible causes for inaccuracy. There is no BAR 74 specification for leaks. It is also possible to perform a leak check on a BAR 74 analyzer by sealing the probe tip and turning the motor on. If low flow is indicated, there are probably no major leaks. Machine damage can sometimes result.

All BAR 80 analyzers have a vacuum gauge to be used to check for leaks. The probe must be designed so that a cap or tube can be placed over the probe tip. For weekly leak checks in California by Blue Shield station operators, the probe is sealed with the pump on. Vacuum rises to 12 to 25 inches of mercury and the pump is turned off. Vacuum decay time is then analyzed. If the vacuum drops more than 10 inches of mercury in one minute, it is evidence of a leak. State auditors on monthly inspections do not use this procedure, however. As with BAR 74 analyzers, a calibration gas is drawn through the probe. A discrepancy of greater than 3 percent results in a check for leaks as one of the possible causes for inaccuracy.

EPA specification analyzers are not required to have a vacuum gauge but are required to have inherent leak check capability. Preliminary designs have a recepticle to put the probe in. Circuitry then performs the comparison of measured values from the probe and calibration point.

2.1.3.2 Evaluation--

All analyzers have the capability to be leak checked according to the 207(b) requirements. No existing programs require leak checks performed in this manner.

To meet the 207(b) requirements, a weekly comparison of measured values through the calibration port and through the probe will be necessary. This procedure, however, can be combined with the gas calibration procedure described in Section 2.1.2. The calibration gas drawn through the probe can serve as the gas calibration procedure and half of the leak check procedure. The state auditor should also perform the 207(b) required procedure on a monthly basis.

2.1.4 HC Hangup

2.1.4.1 Overview--

HC hangup refers to the process of hydrocarbon molecules being absorbed or condensed prior to reaching the analyzer detector, primarily in the sample line. There are no regulations requiring an HC hangup check. EPA recommends use of a computerized analyzer that performs an HC hangup check before every test. On ETI, BAR 74, and BAR 80 specification units, the only way to check for HC hangup is to read the HC concentration after the electrical zero/span check is made. The HC concentration is usually between 0 and 15 parts per million (ppm) before the probe is inserted into the tailpipe. The low concentration is usually due to permitted zero drift and hexane in the ambient air. If the HC concentration is 20 ppm or greater and the analyzer is correctly electrically zeroed, HC hangup has occured. On EPA specification units, an HC hangup button must be pressed before each test or the analyzer will not enter the testing mode. No existing decentralized programs require HC hangup checks.

2.1.4.2 Evaluation--

HC hangup is most often a problem at high-volume testing locations where tests are performed at frequent time intervals. This situation will not usually be the case at a decentralized location. The only possible regulation with an ETI, BAR 74, or BAR 80 analyzer is to require that the operator check the HC concentration after the electrical zero/span check but before the test. If the value is greater than 20 ppm HC, the test procedure would not be commenced. This regulation would be even more difficult to enforce than the quality assurance procedures detailed above, but is probably worthwhile because of the minimal cost to implement.

2.1.5 Gas Naming

2.1.5.1 Overview--

Gas naming refers to specifying the gas to be used in gas calibration. Calibration gas is required for use by state auditors, and if gas calibration is performed by the decentralized station operator, by all stations. It is also desirable to have local repair organizations have the same gas. If the gas is not the exact concentration specified on the container, the gas calibration cannot be performed accurately; the difference between analyzer accuracy and improperly named gas cannot be distinguished. The only regulation applicable to gas naming is contained in Section 207(b) wherein it states that the span gas be traceable to NBS gas ±2 percent of the label value.

The basic problem is that NBS gas is prohibitively expensive for widespread use. Practices in existing programs vary widely but can be delineated into three basic procedures:

1. Where only state auditors need gas, the state can buy NBS gas, blend their own gas, or buy gas from a gas blender and check it against the NBS gas (Nevada).
2. In a variation of the first group, the state can blend gas or buy gas in sufficient quantities, check it against NBS gas, and sell calibration gas to decentralized station operators and service organizations.
3. The state publishes specifications for span gas blending. Any gas blender who will abide by the specifications can supply gas to the program. The state buys NBS gas and provides a split of the NBS gas to all certified gas blenders. With this procedure, all gas is traceable to the same NBS gas source although it is blended by more than one gas blender (California).

2.1.5.2 Evaluation--

It is essential that all calibration gas be traceable to a single gas to maintain consistency between state auditors, an estimated 1000 decentralized testing locations, and service organizations. Section 207(b) requires that the gas be traceable to NBS gas. The first procedure is not applicable since decentralized stations will require span gas. With regard to the second procedure, the state has no gas blending capability at this time. Development of this capability, which would duplicate private sector capability, would be quite costly. Because of the large number of potential span gas users, the certified blender approach (third procedure) would place the least burden on the state. The role of the state would be to promulgate gas blending specifications, buy a small quantity of NBS gas to provide splits of certified gas, certify gas blenders, and monitor gas blender performance with regard to quality of span gas sold and price.

The State of California has used the certified gas blender approach for several years and is satisfied with the system. Their gas blender specifications are included as Appendix B. The basic procedure is as follows:

1. Obtain NBS gas certified to be within 1 percent of the label value.

2. Contract with an independent testing laboratory to verify 1 percent NBS gas. Have laboratory manufacture additional gas to within 1 percent of label value. The testing laboratory should use a Beckman 315 instrument or equivalent to measure the gas concentration. The calculation is as follows:

$$\% \text{ deviation} = \frac{\text{master std. value} - \text{blender reported value}}{\text{master std. value}} \times 100$$

where master standard value = value from laboratory instrumentation calibrated with NBS gas

3. Certify precision certified blenders (see Appendix B for requirements).

4. Provide split of 1 percent gas to all blenders.

5. Require, through blender specifications, the quality of gas required (see Appendix B).

6. Perform periodic spot checks of span gas blends. The checks would be performed by an independent testing laboratory.

7. Require the gas blender to recall, correct or replace at their expense any gas or container out of specification.

2.1.6 Internal Log

2.1.6.1 Overview--

An internal log of quality assurance and maintenance activities is a useful device for the station operator and for the state personnel auditing the program. The station operator can use the log as an internal device to schedule and document quality assurance and maintenance activities. State personnel can inspect the log to determine if all required activities are being carried out in a timely manner. Suitable activities to be recorded in the log, by date and person performing the activity involve:

Gas calibration
Leak check
Water trap check
Particulate filter replacement
Analyzer repairs

The 1978 EPA policy memorandum requires maintaining records on the calibration of testing equipment. All existing I/M programs require some kind of recordkeeping.

2.1.6.2 Evaluation--

Cost to the station operator to keep an internal log for each analyzer would be quite low. All log activities could probably be accomplished in ten minutes per week or less. While the log is certainly not tamperproof, it could be inspected by state personnel to monitor quality assurance and maintenance activities. It is recommended that the state develop and print standard log forms and require their use at all testing locations.

2.2 ONGOING AUDIT FUNCTIONS

2.2.1 Data Audit

2.2.1.1 Overview--

One of the major shortcomings of a decentralized I/M program as opposed to a centralized program is the inability of the state to continuously monitor all locations. This shortcoming is partially mitigated by careful analysis of data. The basic procedure is to examine test result data to determine irregularities by inspection station or inspector. A matrix similar to the following could be compiled.

	% passing	Average cost of repair	Repair type
Station	x	x	x
Inspector	x	x	x
Inspector	x	x	x
Station	x	x	x
Inspector	x	x	x
Inspector	x	x	x
Insepctor	x	x	x
Etc.	x	x	x
Program average	x	x	x

There are no federal regulations regarding data audit. However, all existing I/M programs have data audit systems that vary widely with individual program goals and constraints.

2.2.1.2 Evaluation--

This type of data analysis is extremely effective in identifying abuses of the program. Stations or individual inspectors passing an abnormally high number of vehicles, charging an abnormally high amount for repairs, and performing the same repairs on all vehicles can be readily identified. While occasional violations would not be spotted, chronic violations could be delineated. Missouri already uses a similar data audit program in connection with the vehicle safety inspection program. Pass/fail data by station are analyzed. The chief drawback to enlarging such a system to include the emissions test data is the computer cost to compile the data in the matrix format. This is particularly true of the repair type indicator that requires a normalization of values. It is recommended that the state compile emissions test data on percent passing and average repair costs and investigate costs of compiling repair type data.

2.2.2 Undercover Vehicles

2.2.2.1 Overview--

The concept of using undercover vehicles involves a state employee taking unmarked vehicles with known mechanical problems and emission levels to a testing location for an inspection and maintenance test. A comparison of actual and reported results can be used to determine the integrity of the testing location and inspector. There are no federal regulations governing this practice. Several existing I/M programs use this technique.

2.2.2.2 Evaluation--

Use of undercover vehicles can be effective in determining violations of the program. The state already uses this enforcement tool in connection with the safety inspection program. The main drawback to expanding the program to include emissions tests is expense. Labor cost is involved in modifying the vehicle, taking the vehicle to the testing location, repairing the vehicle, filing reports, etc. A pool of vehicles that will not be recognized is also required. Because of the costs involved, the technique is usually restricted to a followup procedure for citizen complaints and to irregularities discovered in the data audit. The technique can also be used for random spot checks although probably with less cost effectiveness.

2.2.3 Citizen Complaint Investigations

2.2.3.1 Overview--

Initiation of the I/M program will doubtless cause many real and imagined consumer transgressions. To effectively followup these consumer complaints, personnel need to be designated to perform the function. There are no federal regulations regarding handling of citizen complaints. All programs have some provision for investigating citizen complaints but the emphasis on the activity varies widely. Most responsive of existing programs is California where the program is under the jurisdiction of the Consumer Affairs Bureau.

2.2.3.2 Evaluation--

Interviews with persons at existing programs indicated that there were large numbers of consumer calls during the first year of the program. In Phoenix (annual testing) and in Los Angeles (change of ownership testing), the number of calls was well over 100 a day through the first year. The calls concerned questions about how the system worked, testing locations, hours, and complaints. Since the emissions testing in Missouri will be combined with the existing mechanical inspection, some consumer education has already occured. However, it is reasonable to assume a significant number of consumer calls at least during the first year. It is recommended that at least two personnel be added to the program to handle citizen complaint investigations. One person would be available by phone during business hours while the second person could assist the first with calls and also perform field investigations.

2.2.4 Challenge Station

2.2.4.1 Overview--

A challenge station is a referee station operated by the governing body where a motorist can obtain an emissions test to compare to a test from a licensed station. It serves as a quality assurance measure because the motorist can compare readings taken by an accurate state operated facility with readings taken at a decentralized testing location. The EPA 1978 policy memorandum requires a challenge station for all decentralized programs.

While the primary purpose of the challenge station is to act as a referee, the challenge station can be used for additional tasks. In Nevada for example, challenge station personnel also grant waivers, license inspection stations, give mechanics tests, license mechanics, and license fleet test locations.

2.2.4.2 Evaluation--

A challenge station is an expensive quality assurance measure. However, EPA will not approve an I/M program without one. Addition of several other functions to the station, such as in Nevada, helps to lower the cost of this quality assurance program.

REFERENCES

PEDCo Environmental, Inc. 1981. Support Document for Development of the Missouri Inspection/Maintenance Program--Emission Analyzer Specifications. Kansas City, Missouri.

SECTION 3.0

FINDINGS

3.1 RECOMMENDED QUALITY ASSURANCE PROGRAM ELEMENTS

Recommended elements of a quality assurance program are shown on Table 3-1. Active participation is required by testing location personnel and state personnel.

For the station operator, an electrical zero/span check and HC hangup check are recommended to be performed before each test. Weekly single point gas calibrations, leak checks, and log entries are also recommended. Span gas should be purchased by each station from a gas blender certified by the state.

It is recommended that state inspectors inspect each location monthly to perform or verify analyzer related, gas naming, and internal log quality assurance procedures. Several ongoing audit functions are also recommended for state consideration. These functions are data audit, undercover vehicles, citizen complaint investigations and challenge stations. The first three of these four functions would represent expansions of audit programs included in the existing safety inspection program.

3.2 STATE PERSONNEL AND EQUIPMENT COSTS

Estimated first year costs, for quality assurance, accrueable to the state are shown in Table 3-2. The Missouri Highway Patrol estimates the need for eight motor vehicle inspectors, two data clerks and one programmer to support the program (Missouri Air Conservation Commission 1980).

The estimate of eight additional motor vehicle inspectors is based on the assumption that an additional 15 minutes inspection time, over the inspection time for the safety inspection program, would be required to perform emission test related inspections for quality assurance. Fifteen minutes is an adequate period of time to perform the quality assurance procedures recommended. First year costs for the additional motor vehicle inspections was $150,500 excluding capital costs.

TABLE 3-1. RECOMMENDED ELEMENTS OF A QUALITY ASSURANCE PROGRAM

	Frequency	
Element	Performed by decentralized station operator	Performed or checked by state personnel
Analyzer related		
Electrical zero/span	Before each test	Monthly
Gas calibration	Weekly	Monthly
Leak check	Weekly	Monthly
HC hangup check	Before each test	Monthly
Gas naming	As required	Monthly
Internal log	Weekly minimum	Monthly
Continuous audit functions		
Data audit		Continuously
Undercover vehicles		Continuously
Citizen complaint investigations		Continuously
Challenge station		Continuously

TABLE 3-2. ESTIMATED FIRST YEAR COST OF QUALITY ASSURANCE PROCEDURES TO THE STATE

Salaries	
Inspectors (8 persons)	$158,488
Data clerks (10% of time)	2,260
Programmer (10% of time)	2,200
Citizen complaints (2 persons)	39,622
Challenge station operators (4 persons)	49,244
Equipment and Expendables	
Emission analyzers for challenge station (3 analyzers amortized over 5 years)	3,300
Calibration gas for inspection and challenge station (80 bottles at $70/bottle)	5,600
Calibration related equipment (24 sets for inspectors + 2 sets for challenge station + 4 spares = 30 sets amortized over 5 years)	900
Challenge station costs:	
First year lease cost	14,000
Improvements (amortized over 5 years)	7,000
Utilities, insurance	3,000
CPU time for data analysis	4,000
	$319,614

Sources: Missouri Highway Patrol 1981.
Missouri Air Conservation Comission 1980.
Missouri Department of Natural Resources 1981.
Environmental Tectonics Corporation 1980.

The two clerks and programmer would have functions that included other activities as well as quality assurance related functions. Their quality assurance related duties would chiefly be limited to the data audit functions. Since no additional data would be gathered for the audit check beyond that already being collected for program evaluation, their time would be limited to running the audit computer program and analysis of results.

It is recommended that at least two additional personnel be retained to handle citizen complaints. One of these persons would be responsible for handling all citizen complaints submitted by phone, mail, or in person. The second person would be responsible for assisting the first person and for field investigations of citizen complaints, including the use of undercover vehicles. This recommendation is based on reports from existing programs, particularly in Los Angeles (change of ownership testing) and Phoenix (annual testing), that recorded well over 100 phone calls a day during the first year of program implementation.

The Missouri Department of Natural Resources (Missouri Department of Natural Resources 1981) estimates the need for four persons to service the challenge station. Two persons would be at the challenge station continuously while the other two persons would perform quality assurance checks at the testing locations.

Equipment and expendables include costs related to the challenge station (rent, improvements, utilities, emission analyzers, and calibration equipment) and to the inspectors (calibration gas and related equipment).

Based on these data, estimated costs to the state in the first year for quality assurance would be $319,600, or about 32¢ per car assuming 1,000,000 vehicles are inspected each year.

REFERENCES

Environmental Tectonics Corporation. 1980. Spare Parts List.

Missouri Air Conservation Commission and Missouri State Highway Patrol. 1980. Proposed Inspection/Maintenance Program for Missouri. Final Report.

Missouri Department of Natural Resources, Air Pollution Control Program. Telephone conservation with C. Lamb.

Missouri Highway Patrol. 1981. Telephone conversation with Sergeant L. Walker.

APPENDIX A

OVERVIEW OF QUALITY ASSURANCE PROCEDURES FOR EXISTING I/M PROGRAMS

Following are brief summarizations of the QA tasks that are followed by the existing I/M programs.

Each month, state officials in New Jersey calibrate the analyzers at the state inspection lanes. In addition, New Jersey officials visit each certified reinspection station at least once every 2 months in order to verify the accuracy of the analyzers and to inspect records. The officials look at both the recorded emission levels and the charges to the customer in order to determine if proper repairs are being performed. In some cases the officials will reinspect vehicles with unusual or questionable repairs. New Jersey also independently surveys about 12,000 vehicles to gather additional data about the program. Some of these data can be used for QA analysis. To aid in the quality of inspections and repairs, New Jersey also provides garages with specifications for portable analyzers as well as a list of analyzers which comply with these requirements.

Arizona performs several types of quality assurance tasks. Test data are analyzed to verify the contractors' charges to the state. Officials also survey the stations and verify the accuracy of the analyzers used at the inspection lanes at least once every two weeks. The contractor calibrates the equipment on a weekly basis. Officials verify analyzer accuracy at the fleet inspection stations at least once every 90 days. In addition, in Arizona a repair facility may voluntarily register an emission analyzer with the state. These registered analyzers are checked for accuracy initially upon registration and at least once each 90 days thereafter.

Like Arizona, California also performs surveillance of the contractor and fleet testing facilities. The contractor stations are inspected every 2 weeks for analyzer and inspection accuracy as well as for proper housekeeping. In addition, other equipment such as the report printers, data entry terminals, and ambient carbon monoxide (CO) monitors are checked for calibration and correct system operation. A leak check of the entire sampling system is also conducted. Fleets are inspected every two months for analyzer accuracy and proper completion of forms. In addition, the fleets may be asked to demonstrate certain repair and diagnostic procedures. California also submits selected inspected vehicles for reinspection at the fleet stations. The contractor and the fleets are required to calibrate the analyzers weekly.

Nevada also devotes considerable time to quality assurance. Officials visit each inspection station at least once per month in order to verify the accuracy of the emission analyzer and to collect records. Some of the records are then examined in order to determine the reasonableness of the charges and repairs. During the visits, the officials check to see that the station has current service manuals with correct tune-up specifications. Nevada also performs spot checks on some of the inspection stations. An unidentified person will have an inspection performed on an incorrectly operating car, such as a vehicle with a spark plug wire removed. Garages will usually be investigated in this manner as a result of complaints or challenge station checks, although Nevada tries to spotcheck each garage at least twice a year. Additionally, Nevada requires that all waiver cases first be checked by an official at the challenge station before approval. This requirement helps to identify garages that need to be investigated. At the end of 1979, Nevada had revoked the licenses of 6 stations because of failure to perform the inspections correctly. In addition, 15 to 20 percent of the analyzers were red-tagged each month. When an analyzer is red-tagged, the state confiscates the forms and the analyzer must be repaired (or calibrated) before the station may resume inspections. (To overcome the possibility of not being able to conduct inspections, many garages have more than one analyzer). On the whole, Nevada officials feel that the garages are doing a good job.

Oregon has always been concerned about good quality assurance. For the first few years of the program, analyzers were calibrated hourly and the stations were visited frequently by DEQ inspectors. Now the lead inspector calibrates the analyzer hourly during the morning when they are warming up and then every three hours after that, or more frequently if they seem to require it (a minimum of five times per day). It was reported that the analyzers hold calibration very well. Each station has at least one extra analyzer if difficulty arises. All stations are visited at least once a week by a DEQ engineer/supervisor and the 50 fleet inspection stations are visited at least once a month. In addition, an unannounced calibration visit is made to the stations monthly, featuring cross reference testing of analyzers from different stations. As a result of these precautions, Oregon has had very few quality assurance problems at the lanes. However, Oregon officials are still concerned over the quality of the repairs and feel that the program may benefit from closer control of the retests. (Oregon has unlimited retests.)

Rhode Island officials make monthly visits to the licensed garages and have the station personnel demonstrate a calibration of the analyzers. While they are at the garages, they check the calibration records and collect the emission test reporting forms. (The garages must calibrate the analyzers weekly.) In addition, some state vehicles are equipped with emission analyzers which can be used in the roadside safety checks. In 1979 emissions were checked in approximately 5,000 of the 26,000 roadside checks.

In 1979 Rhode Island suspended the licenses of 13 garages for violating the inspection requirements. However, all of these suspensions were for improper safety inspections and not specifically emission inspections. Officials in Rhode Island's inspection department report few emission related problems, although there is little accurate data on the emission failure rate. However, in the monthly garage inspections, officials note that 14 percent of the analyzers are initially out of calibration. After the garages demonstrate a calibration, about 3 percent of the analyzers are still out of specification (plus or minus 5 percent).

In Cincinnati, the analyzers are calibrated every month as part of a service agreement with the manufacturer. Cincinnati performs few additional quality assurance tasks and has experienced problems with large fluctuations in failure rates. However, these problems are minor in comparison with the enforcement problems in Cincinnati.

In New York, the analyzers are calibrated every month by the contractor. The contractor also picks up the data which is recorded on a cassette tape which is located in the analyzer. The data is then further reduced by the contractor. The state inspects the stations bi-monthly and examines the analyzer and its calibration records along with records identifing the vehicles that have been inspected and the readings of hydrocarbon (HC) and carbon monoxide (CO) from the emissions tests.

APPENDIX B

CALIFORNIA CERTIFIED GAS BLENDER SPECIFICATIONS

STATE OF CALIFORNIA—AGRICULTURE AND SERVICES AGENCY
EDMUND G. BROWN JR., Governor

DEPARTMENT OF
Consumer Affairs

BUREAU OF AUTOMOTIVE REPAIR
3116 BRADSHAW ROAD, SACRAMENTO, CALIF. 95827
PHONE: (916) 322-2880

March 5, 1975

Distribution: PRECISION GAS BLENDERS

Subject: REQUESTS FOR GAS BLENDER CERTIFICATION

Gentlemen:

Based on pending regulations, all precision gas blenders desiring to supply exhaust analyzer calibration gas to approximately 10,000 official stations in California must be certified by the Bureau of Automotive Repair (BAR).

Your response to the proposed California gas standard for use in calibration of HC/CO infra-red emission analyzers has been very encouraging. We have consolidated the comments and suggestions from the many interested people in order to draft the finalized version that is attached. This resulting standard, which has been adopted by the Bureau, represents the requirements for a uniform containerized gas blend to be authorized for use in Class A Official Pollution Control Stations in California.

In accordance with the standard, your procedure for obtaining BAR certification is as follows:

1. Submit documentation required by the attached standard to the Bureau of Automotive Repair, 3116 Bradshaw Road, Sacramento, California 95827.
2. After receiving notification of acceptance of this material by BAR, obtain a sample of the master gas blend from a laboratory to be designated by the Bureau.
3. Submit two production cylinders of your calibration gas blended in accordance with the standard to the laboratory supplying the master gas sample or other test facility indicated by the Bureau. The analysis of your gas must be within 2 percent of the label values with the master gas as a reference.
4. Forward to the Bureau a copy of the laboratory analysis indicating that your blend conforms to the standard.

5. Providing all documentation and test data is in conformance with the standard, the BAR may issue your certification and include your organization on the approved blender list.

We urge you to request certification of your product by submitting the required documentation as soon as possible. Subsequently, industry and calibration gas users will be informed of all approved gas blenders on a continuing basis.

Sincerely,

ROBERT C. ALEXANDER
Chief

RCA/DEG/jml

Attachment - Calibration Gas Standard

STANDARD FOR CALIBRATION GAS FOR HC/CO EMISSION TESTERS

SECTION 1

GENERAL PROVISIONS

Infra-red hydrocarbon and carbon monoxide emission testers require calibration at designated intervals to maintain validity of spark ignition engine emission test results. This standard applies to the calibration gas and portable container to be used for calibrating HC/CO emission testers in the state of California Class A Pollution Control Inspection Stations.

1.1 Scope

The scope of this standard encompasses:

Section 1 - General Provisions and Definitions
Section 2 - Requirements
Section 3 - Gas Blender Certification
Section 4 - Quality Assurance
Appendix A - Reference Documents List
Appendix B - Blended Gas Label
Appendix C - Application For Certification

1.2 Definitions

1.2.1 Blend Tolerance - the maximum percent deviated from the desired concentration of the gas (blend of HC and CO) components.

1.2.2 Analytical Accuracy - the relative percent deviation of the blender's reported concentrations of HC and CO gas components from the BAR master standards.

Example:

$$\text{\% Deviation} = \frac{\text{*Master Std. Value - Blender Reported Value}}{\text{*Master Std. Value}} \times 100$$

*Value from laboratory instrumentation calibrated with BAR master standard.

Reproduced from best available copy.

1.2.3 Calibration span gas - a blend of hydrocarbon (HC) and carbon monoxide (CO) gases with nitrogen (N_2) as the balance or carrier gas used for adjusting HC/CO exhaust analyzer test instruments to a predetermined calibration value for the measurement scale used.

1.2.4 Chemically pure gas - a high quality gas known as CP grade in the industry. Typical minimum purity shall be: propane, 99.5%; carbon monoxide, 99.8%; nitrogen, 99.997%.

1.2.5 Qualified gas blender - a precision gas blender approved by the Bureau of Automotive Repair capable of providing continuous quality gas blends within the limits of this standard.

1.2.6 Authorized gas distributor - a company authorized by a qualified gas blender to distribute (in approved containers) gas blends produced by the qualified gas blender meeting all requirements of this standard.

1.2.6.1 Repackager - an approved gas blender or his authorized representative responsible to assure by laboratory analysis that the accuracy of the gas blend in repackaged or refilled containers complies with the requirements of Section 2 of this standard.

1.2.7 BAR - Bureau of Automotive Repair (approving agency), State of California, 3116 Bradshaw Road, Sacramento, California, 95827.

1.2.8 California BAR master standard - a primary gas blend standard established by BAR for use in California and traceable to the NBS through ARB standards.

1.2.9 Traceable - to be able to compare on a laboratory quality gas analyzer, calibrated with a master standard blend, a sample gas blend to the master or primary standard gas blend within stated tolerance limits.

SECTION 2

2.1 Requirements

2.1.1 The calibration span gas blend and portable container units shall comprise the following items:

a. Gas blend - calibration span gas shall have a blend tolerance not exceeding 5% and shall consist of a blend of 3,000 ppm ±150 ppm of propane (HC) and 8% ±.4% carbon monoxide (CO) in an inert balance gas of vaporized liquid nitrogen (N_2). The analytical accuracy of the blend shall be certified to be within ±2% of label values. Direct comparison shall be made to the California BAR master standard blend traceable through Air Resources Board (ARB) as outlined in paragraph 4.1.1 of this standard.

a.1 Component gas (HC and CO) purity shall be stated in the analysis and have a guaranteed chemically pure quality as defined in paragraph 1.2.4.

a.2 Balance gas purity - the N_2 balance gas shall be chemically pure grade as defined in paragraph 1.2.4.

b. Containers (standard type) - Requirements for the recommended gas blend container are as follows:

b.1 Nonrefillable - a low pressure (260 psi nominal) portable container approved by BAR.

b.2 ASME Unfired Pressure Vessel Code, Section VIII (260 psi service, 325 psi proof, 500 psi burst) minimums.

b.3 Federal requirements - the applicable Department of Transportation (DOT) specification for shipping containers of compressed gas shall be complied with. See Appendix A.

b.4 Nominal size - 750 cubic inches ±5% (approximately 9 inches inside diameter by 16 inches high overall, providing an equivalent water capacity not to exceed 55 lbs.).

b.5 Shutoff valve approved by CGA for gas service at pressure specified in 2.1.1.b.1 above with threaded male outlet or adaptor to accept a 1/4" AN fitting to connect gauge, regulator and discharge hose assembly.

b.6 Safety shield on container top to protect valve.

b.7 Container color - white enamel, exterior grade compatible with all types of automotive service operating environments.

b.8 Container material and compatibility - any container material, weld flux, antiseize compound, paint, etc., shall not be used in container assembly or charging equipment which could cause contamination or degradation to or is incompatible with the gas blend. All containers must comply with the applicable California and Federal DOT, OSHA, ASME requirements and California Division of Industrial Safety and must be approved by the BAR.

b.9 Container precharging preparation - prior to blended gas charging, each container will be purged with vaporized liquid nitrogen or the blended gas for a minimum of two minutes followed by evacuation to industry accepted conditions.

b.10 Stability - container shall be designed to be stored in an upright position.

c. Containers - special types - Gas blenders or suppliers organized to provide calibration gas in higher pressure rechargeable containers shall submit a request to the BAR for approval. The request shall include notation of the applicable DOT and ASME code compliances, details of recommended regulator compatible with approved emission testers, CGA valve, container size and weight, and quality assurance tests conducted.

d. Safety legend - caution notes shall comply with the applicable DOT and OSHA regulations.

e. Identification - a gummed label acceptable to BAR, indicating in ink, gas blender, DOT #, gas mixture analysis, certified analytical accuracy tolerance (%), date filled and lot number, shall be securely affixed to upper side of container. NOTE: Gummed labels (see Appendix B) may be procured from BAR, 3116 Bradshaw Road, Sacramento, California, at time of gas blender certification.

SECTION 3

3.1 Gas Blender Certification

a. Gas blenders supplying calibration gas for use in the state of California emissions testing program must be certified by the BAR. The gas blender's capability to produce precision gas blends and maintain analytical accuracy within ±2% of the California BAR master standard must be demonstrated to BAR in the application for certification (Section 3.2).

3.2 Application for Certification

3.2.1 General Data and Product Sample Required

a. Submittal package: application forms shall be completed and submitted to the Department of Consumer Affairs, Bureau of Automotive Repair, 3116 Bradshaw Road, Sacramento, California, 95827. The application must be signed by an officer of the gas blending company.

a.1 Descriptive information:

1. Application form
2. Gas blenders facility description
3. Instrumentation utilized
4. Production capabilities
5. Estimated selling price (to user) per container of blended gas in lots of 1-10, 1-20, 100 up, etc.)
6. Business status report: Gas blenders and distributors shall submit the following information with their request for certification:
    a. Indication that the applicant is a bona fide gas blender or distributor of precisions gas blends.

    b. Evidence that the applicant is either a California corporation or a registered out-of-state corporation.
    c. Annual sales volume during the previous fiscal year.

7. Marketing plan: A marketing plan shall be submitted which includes the following explicit information as a minimum:
    a. Statewide distribution methods preferably including toll free telephone systems for emergency conditions.
    b. A clearly defined method of disposition and replacement of nonconforming products.
    c. Gas filled container lot control details.
    d. Provisions for product delivery to local distributors within 30 days of certification.
8. Liability bonding information ($300,000 minimum per occurrence): A copy of product liability insurance which shows adequate protection in catastrophic failure conditions (container or valve rupture, noxious gas leakage, etc.) shall be submitted. Evidence of distributor bonding coverage throughout the state shall be provided.
9. Container information and manufacturer's test results (source, type, handling procedure, and lot control of containerized gas units for statewide traceability).
10. Assurance that compliance with all applicable OSHA/Cal OSHA standards have been made.
11. Brief description of facility quality control program.

a.2 Product sample: Two samples of blended gas (in approved containers) from two lots shall be submitted to a laboratory designated by the bureau for comparison with the California BAR

HC/CO blend in accordance with Section 4. Comparison of the blended samples to the master standard gas on BAR designated laboratory equipment must be within ±2% of hte label value to satisfy the analytical accuracy and traceability requirements of this standard.

SECTION 4

4.1 Quality Assurance - Initial certification of gas blenders and all gas blend procurement will be dependent on assurance that requirements of Section 2 of this standard have been satisfied. Test data noted below shall be provided by the gas blender.

a. Sample span gas blends analysis test results compared to the California BAR master standard gas as a reference as tested on a laboratory quality gas analyzer by the ARB laboratory or a laboratory specified by the BAR. Component and balance gas manufacturer's purity certification shall demonstrate compliance with the applicable paragraphs of Section 2.

b. Container manufacturers' data indicating compliance with 2.1.1.b through 2.1.1.b.10 shall be submitted. Pressure test data and assurance of compliance to applicable DOT, ASME, and OSHA specifications shall be provided.

NOTE: Periodic spot retesting of span gas blends after acceptance may be made by BAR. It will be the gas blender's responsibility to recall, correct, or replace at their expense any blended gas or container assembly found by the bureau to be deteriorated or out of specification for any reason within one year after purchase. The BAR standards for judgements in these matters will be traceable to the Air Resources Board master standards.

REFERENCE DOCUMENTS LIST

CALIBRATION GAS STANDARD

Documents listed for reference and additional sources of information.

1. Calibration Exhaust Emission Standards and Test Procedures for 1971 and Subsequent Model Gasoline Powered Motor Vehicles Under 6001 Pounds Gross Vehicle Weight: California Air Resources Board, Sacramento, California, November 20, 1968.

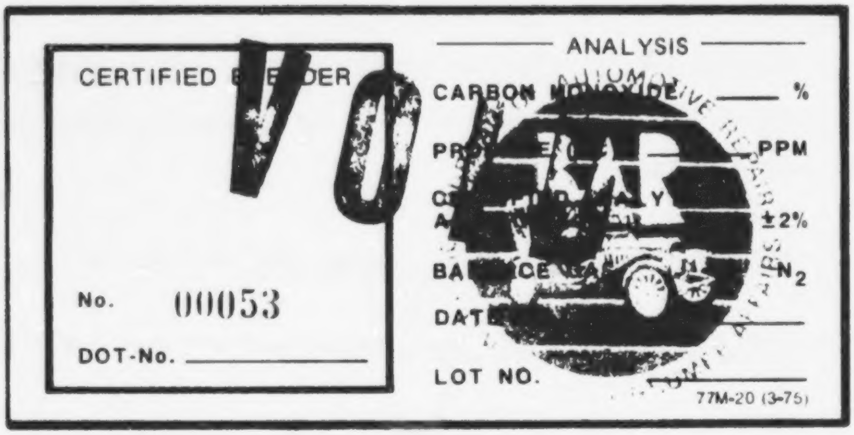
2. Control of Air Pollution from New Motor Vehicles and New Motor Vehicle Engines: Federal Register Volume 33, Number 108, Part II July 4, 1968.

3. Federal Register Volume 36, Number 105, May 29, 1971.

4. Code of Federal Regulations, Department of Transportation.

5. ASME Unfired Pressure Vessel Code, Section VIII.

BLENDED GAS LABEL



CERTIFIED BLENDER

No. 00053

DOT-No. __________

VO

ANALYSIS

CARBON MONOXIDE ____ %

PRO[illegible] ____ PPM

C[illegible] Y
A[illegible] ±2%

BALANCE GAS N_2

DATE __________

LOT NO. __________

BAR

77M-20 (3-75)

APPLICATION FOR CERTIFICATION

1. General: Tab A is a sampbe certification application form. Broad guidelines are contained in the following paragraphs. Tab B is a summary checklist to be completed and certified by the applicant and/or a laboratory acceptable to the bureau.

   a. Bureau Policy: The bureau does not intend to undertake to sponsor development or research testing of gas blending operations but instead will confirm the blenders' test data according to the evaluation procedures outlined in Sections 3 and 4.

   b. Proprietary Information: The bureau will handle all proprietary technical data contained in the application as confidential.

   c. Additional Information: If space provided on the application is insufficient, enter "See attached sheet #1 or #2, etc." and use a separate sheet for each item.

   d. Completeness: The form should be filled in as completely as possible. However, if information on some items is not available, so indicate and state the reasons therefore.

   e. Cost Estimates: Cost estimates should be based on a quantity production type of operation. Wholesale and retail cost estimates are costs to the user rather than manufacturing costs.

   f. Sale of Company Assets: The bureau shall be notified in writing 90 days prior to the sale of a company. The new owners must submit a new application for certification and obtain written bureau approval.

SAMPLE APPLICATION FORM FOR GAS BLENDER CERTIFICATE

1. Date of Application ______________________

2. The authorized representative of ______________________ (company, corporation, or subsidiary) hereby applies for certification as an approved calibration gas blender for the state of California Auto Emissions Control Program.

______________________ Authorized Signature

______________________ Full Company Name

______________________ Address

____

______________________ Phone Number

3. Location of major distribution centers (in California).

______________________ ______________________

______________________ ______________________

4. Estimated date containerized blended gas will be available ______________________.

EVALUATION DATA CHECKLIST

(Submit in Order Shown)

1. APPLICATION FOR CERTIFICATION

2. DESCRIPTIVE INFORMATION

   A. The gas blender's facility description;

   B. Instrumentation utilized;

   C. Production capabilities;

   D. Estimated retail cost per container to user (in lots of 1-10, 10-20, 100-up, etc.) (may be handled by letter included within the submittal package);

   E. Business status report;

   F. Marketing plan information in accordance with paragraph 3.2.1.a.1.7;

   G. Copies of insurance documents;

   H. Container information and manufacturer's test results;

   I. OSHA compliance statement; and

   J. Quality control plan.

3. TEST RESULTS - Comparative analysis of samples by number to the California master standard with percent deviation should be tabulated. NOTE: Include test conditions and instruments utilized by model and manufacturer.

ADDRESSES OF CERTIFIED CALIBRATION GAS BLENDERS

The following are approved suppliers of calibration gases for exhaust analyzers as of January 20, 1980. Use this list to update page 48 of your MVPC handbook:

Airco Industrial Gases Division
1588 Doolittle Drive
San Leandro, California 94577

Liquid Carbonic Corporation
5700 South Alameda Street
Los Angeles, California 90058

Horiba Instruments, Inc.
Irvine Industrial Complex
Santa Ana, California 92705

Union Carbide (Linde Division)
19200 Hawthorne Blvd.
Torrance, California 90503

Scott Environmental Tech., Inc.
2600 Cajon Blvd.
San Bernardino, California 92411

Matheson Gas Products
8800 Utica Street
Cucamonga, California 91730

Air Products and Chemicals, Inc.
23320 So. Alameda Street
Long Beach, California 90810

APPENDIX C

SAMPLE STATE INSPECTION REPORT FORMS FROM NEVADA AND CALIFORNIA

AUDIT FORM FOR NEVADA

Procedures for Conducting an Authorized Station Inspection

1. Use authorized station checklist as follows:
   - a. Check if all licenses are displayed in a conspicuous place, under glass or other transparent material.
   - b. Check if a sign indicating the set fee or hourly rate is posted in a conspicuous place and meets the requirements listed on the checklist.
   - c. Record the number of inspectors.
   - d. Inspect the available manuals for adequate information and list the specification manuals.
   - e. Inspect the tune-up equipment for condition and operating capability.
   - f. Check the emission reports records for completeness and availability.
   - g. Check for availability and proper use of compliance certificates.
2. Use the following procedure to check the calibration of the exhaust gas analyzer.
   - a. Have operator warm up and calibrate the equipment.
   - b. Using the plastic bottle with holes in it, insert the sample probe through the bottom of the bottle and the gas sample valve stem in the top. Release just enough gas to pressurize the bottle for 3 or 4 seconds. Record readings on check sheet. Transfer gauge and valve to the second gas sample and repeat above. Compare recorded readings with the sample gas values. Readings should be within ±10%; 5% high or 5% low.

DATE ____________________________

EA # ____________________________

S ATION NAME ____________________________ NO. OF INSPECTORS ________

A RESS ____________________________

	Yes	No
L cense displayed		
Station		
Inspectors		
Regulation sign posted		
R ferences available		
State exhaust emission standards		
Specification manual		
Titles		
Tune-up equipment		
A e the inspection records available and complete		
A e the Certificate of Compliance forms available		
Are they filled out properly		
Remarks		

____

Type of infra red equipment ____________________________ Model ________

S rial Number ____________________________

****

Calibration Test

Tolerances

C rrelation factor ________

Propane ________ PPM

H PPM ____ ________ ____
Hi Standard Low

C % ____ ________ ____
Hi Standard Low

			Time
1st test reading:	CO ________ %	HC ________ PPM	________
2nd test reading:	CO ________ %	HC ________ PPM	________
3rd test reading:	CO ________ %	HC ________ PPM	________
4th test reading:	CO ________ %	HC ________ PPM	________

****

OUT OF SERVICE

Yes No

REASON: Failed to pass calibration test ________ :License under revocation ________

Approved Inspector not employed ________ :Failure to renew license ________

Failure to keep bond in force ________ :Other ________

____

____

****

ast Certificate of Compliance issued on ____________ 19 ___. Cert.# ________

This equipment cannot be used for the issuance of a certificate of compliance until released by an agent of the Emission Control Section of the Department of Motor Vehicles. 386-5356.

tation Authorized Representative ____________________________

mission Control Officer ____________________________

Back in Service: Date ____________ 19 ___; Time ____________ AM ________ PM ____

mission Control Officer ____________________________

AUDIT FORM FOR CALIFORNIA

M.V.I.P. INSPECTION REPORT

FLEET NO.	MVPC NO.	ARD NO.	DATE

FACILITY NAME

ADDRESS	CITY	ZIP
PHONE NO.	NO. OF CERTIFICATES ISSUED PER WEEK	

OWNERS NAME OR RESPONSIBLE MANAGING EMPLOYEE (PRINT)

TYPE INSPECTION
- ☐ INITIAL
- ☐ FOLLOW UP
- ☐ PERIODIC

- ☐ COMMERCIAL FLEET
- ☐ DEALER FLEET
- ☐ COLLECTIVE FLEET
- ☐ QUALIFIED

ANALYZER CALIBRATION INFORMATION

BRAND NAME	MODEL	SERIAL NO.	C3/C6 FACTOR	DATE LAST CALIBRATED

CORRECTED CAL GAS VALUES

HC ________ PPM PROP. x FACTOR ________________ PPM HEX

± 100 PPM ACCEPTABLE RANGE ________ TO ________ PPM

CO BOTTLE VALUE ____________ %

± .4% RANGE ________ TO ________ %

ANALYZER ACCURACY CHECK

METER READINGS			ACCEPTABLE	
HC THRU CAL PORT	________	PPM	☐ YES	☐ NO
HC THRU PROBE	________	PPM	☐ YES	☐ NO
CO THRU CAL PORT	________	%	☐ YES	☐ NO
CO THRU PROBE	________	%	☐ YES	☐ NO

REMARKS I-R ANALYZER ONLY

GENERAL INSPECTION ITEMS

GENERAL INSPECTION ITEMS	YES	NO		YES	NO
1. OFFICIAL SIGN DISPLAYED			9. RECORD OF NOx STICKER MAINTAINED		
2. CURRENT STA. LIC./ REG POSTED			10. RECORD OF CERT/ WORK ORDERS MAINTAINED		
3. CURRENT EMPLOYED LIC. INST./ADS.			11. REQ. TOOLS & EQUIP. AVAIL. & SERVICEABLE		
4. CURRENT EMP. INST./ ADS. LIC. (s) DISPLAYED			12. BAR BULLETINS, MECH. HANDBOOK CURRENT		
5. PRICES POSTED			13. TUNE UP SPECS. & SERV. DATA CURRENT		
6. INSPECTION PROCEDURES POSTED			14. HAVE RECEIVED FLEET TRAINING		
7. REG. INSPECTION STEPS FOLLOWED			15.		
8. CERTIFICATES ISSUED CORRECTLY			16.		

COMMENTS:

QUALIFIED / CLASS 'A' MECH. QUALIFICATION NO.	CLASS 'A' NO.	QUALIFIED / CLASS 'A' MECH. QUALIFICATION NO.	CLASS 'A' NO.
QUALIFIED / CLASS 'A' MECH QUALIFICATION NO.	CLASS 'A' NO.	QUALIFIED / CLASS 'A' MECH QUALIFICATION NO.	CLASS 'A' NO.
INSPECTOR'S NAME AND I.D. NO.		OWNER /MANAGER	DATE

78M-27 (1/79)

TRIP - OSP

INSPECTION STATION REQUIREMENTS

CONTENTS

Page

1.0 Introduction 1
  1.1 Purpose 1
  1.2 Requirements 1
    References 3

2.0 Inspection Station Requirements 4
  2.1 Space requirements 4
  2.2 Equipment requirements 5
  2.3 Personnel requirements 6
    References 8

SECTION 1.0

INTRODUCTION

1.1 PURPOSE

The purpose of this report is to provide technical information to the State of Missouri on inspection station requirements for a mandatory decentralized inspection/maintenance (I/M) program. This report will serve as the technical basis for the state in adopting regulations for inspection station requirements relative to spatial, equipment, and personnel needs.

1.2 REQUIREMENTS

1.2.1 Environmental Protection Agency Requirements

Environmental Protection Agency (EPA) requirements pertaining to inspection station requirements are contained in a 1978 EPA policy memorandum (Hawkins 1978) and later reiterated in a 1982 document (Gray 1981). Requirements are that a private inspection facility must:

- Be licensed
- Have an emission analyzer that meets state/local specifications
- Employ an inspector with demonstrated proficiency in I/M rules and regulations, test procedures, analyzer use, quality assurance procedures and recordkeeping
- Maintain and submit records related to vehicle inspections
- Submit to unscheduled/unannounced audits

There are no Section 207(b) provisions relative to inspection station requirements.

1.2.2 State of Missouri Requirements

The State of Missouri has inspection station requirements for its vehicle safety inspection program (Missouri State Highway Patrol 1980). Because the I/M program will be coupled with the safety inspection program, requirements for that program are listed below. Minimum requirements are that a facility must:

- Have an inspection area within an enclosed building of sufficient length and width to accommodate a full size domestically made passenger vehicle.
- Be sufficiently lit, adequately heated, and properly ventilated.
- Have a floor that is substantially level and constructed of a hard material, be kept clean, and be free from excessive dirt, grease, and loose material.
- Do no major mechanical repair work in the inspection area during normal business hours if the station has only one inspection area.
- Have the following equipment - brake performance test equipment, brake lining gauge, brake pad gauge, ball joint gauge, lift or jack, scraper, measuring device, and punch.
- Employ a licensed inspection/mechanic. To obtain a license, an applicant must; have one year practical experience as an automotive applicant or have completed a course of vocational instruction in automotive mechanics from a generally recognized educational institution; pass a written test; and demonstrate practical knowledge by inspecting a vehicle.

REFERENCES

Gray, C. L. 1981. Inspection/Maintenance Program 1982 SIP Processing. Ann Arbor, Michigan.

Hawkins, D. G. 1978. Memorandum to Environmental Protection Agency Regional Administrators. Washington, D.C.

Missouri State Highway Patrol. 1980. Missouri Motor Vehicle Inspection Regulations. Jefferson City, Missouri.

SECTION 2.0

INSPECTION STATION REQUIREMENTS

2.1 SPACE REQUIREMENTS

2.1.1 Overview

Spatial requirements for inspection stations vary significantly. For Blue Shield stations in California, no physical dimensions are required but the work area must be "approved by the bureau". Other states such as Nevada give no physical dimensions but rely on descriptive terms such as "sufficient space to test and inspect". As noted in Section 1.0, Missouri now uses a similar approach in the safety inspection program specifying that the test area by "of sufficient length and width to accommodate a full size domestic vehicle". Of existing programs, only Rhode Island specifies minimum dimensions of 13 feet by 25 feet with mechanical headlight aimers or 13 feet by 45 feet without mechanical headlight aimers.

Spatial requirements also vary with respect to specification that the testing area be in an enclosed building, specification of floor material, and specification of heating and ventilation.

2.1.2 Evaluation

The Missouri space requirements for the safety program are as stringent as any found in existing safety or I/M programs except that the size of the testing area is not dimensioned in feet. However the existing regulation requiring that the inspection area be "of sufficient length and width to accommodate a full size domestic made passenger vehicle" could be changed to "of sufficient length and width to test and inspect a full size domestic made passenger vehicle". This wording would require not only sufficient space to accommodate a full size vehicle but also would insure access to the tailpipe for insertion of the probe, and access to the hood area for needed adjustments or repairs.

It is recommended that Missouri retain their existing requirements with regard to enclosure, floor material, and heating and ventilation. Beyond the existing needs of the safety program, emission analyzers are sensitive to dust, temperature variation, and extreme temperatures (PEDCo 1981). The existing requirements would minimize the effects of these factors that are detrimental to analyzer accuracy.

2.2 EQUIPMENT REQUIREMENTS

2.2.1 Overview

Most existing decentralized programs have a list of required equipment. Rhode Island requires an emission analyzer only. The items on the list vary principally by whether a safety inspection is included with the emissions test. Emissions related equipment requirements are related to adjustments or repairs to carburetion and ignition systems, i.e., tuneup functions. Items included are:

- Ignition analyzer-oscilloscope
- Ammeter
- Voltmeter
- Tachometer
- Vacuum gauge
- Pressure gauge
- Cam angle dwell meter
- Ignition timing light
- Compression tester
- Distributor advance tester
- Approved emissions analyzer and related calibration equipment
- Signs
- Manuals

The requirement for an ammeter and a pressure gauge are unique to California.

All programs specify that a sign must be posted. Some programs, such as in Nevada, specify only a minimum size. California and the existing Missouri safety program require a specific sign.

Only Nevada requires that the testing location keep service manuals. The requirement reads:

> Each authorized station shall have adequate information available for the inspection to determine: what state or federal emission control devices are required for specific motor vehicles; and what the motor vehicle manufacturer's emission control performance specifications are for the specific motor vehicle (Nevada Environmental Commission 1979).

The rationale for this requirement is that maintenance of vehicles should consist of returning the vehicle to manufacturers specifications. The station must have these specifications to perform the required adjustments and repairs.

2.2.2 Evaluation

The only equipment necessary to perform an idle vehicle emissions test is an approved emissions analyzer. Other equipment is required only for adjustments or repairs. In the existing Missouri safety inspection program, the only equipment required is for the actual safety inspection and not for repairs to correct safety defects. Therefore, if the philosophy of the safety inspection program was transferred over to the emission testing program, the only equipment required would be the emissions analyzer, such as in Rhode Island. Involved in the question of requiring repair equipment is the judgment as to whether a station operator's ability to perform an objective evaluation of vehicle safety and emission levels is compromised by the ability and desire to perform repairs. This judgment is beyond the scope of this report. If the decision is made to require repair equipment, the list in Section 2.2.1 is appropriate.

It is recommended that Missouri require posting of a specific sign as opposed to setting minimum standards as in Nevada. In Nevada, signs came in all sizes and shapes with some 30 feet or more in length. The result is aesthetically unappealing.

It is further recommended that if repair equipment is required, that service manuals be required by adopting wording similar to the Nevada regulations. While not specifying specific publications, all stations would be required to have all manufacturers' specifications relating to vehicle emission levels.

2.3 PERSONNEL REQUIREMENTS

2.3.1 Overview

The 1978 EPA policy memorandum (see Section 1.2.1) requires that the inspection facility "employ an inspector with demonstrated proficiency in I/M rules and regulations, test procedures, analyzer use, quality assurance procedures and recordkeeping". Existing programs have responded to this requirement in different ways but all require inspectors to be licensed.

For example, in Nevada, an applicant must submit a certificate of competence that indicates ability to perform major motor vehicle tuneups, submit a certificate of competence issued by the manufacturer of the exhaust gas analyzer to be used at the testing location, pass a written test and perform a practical demonstration. At California Blue Shield stations, an applicant must have a certificate of competence to perform a major automotive tuneup to the satisfaction of his employer; or a certificate of competence from a vehicle, device, or tuneup equipment manufacturer, an industrial or trade school, or a public high school or junior college. With such a certificate, the applicant can take the required written test. In Rhode Island, an applicant must have passed a training program approved by the state. In New York, a single specified training course must be completed. In this phased program, the course will be taught by a contractor, later by the state, and later by certified private organizations. The training is based on Colorado State University materials. In Arizona, inspectors at the centralized locations are trained by the contractor and fleet operators are instructed by the state in a seven-hour course.

2.3.2 Evaluation

All programs require licensing of inspectors and a written test. Some programs require taking a specific training program (New York) while most allow different training programs. If the state test is an adequate test of required knowledge, the specification of a specific training program appears unnecessary. Some programs also require a practical test. This further eliminates the need for a specific training program.

It is recommended that the state (or designee) offer a training course consisting of instruction on program procedures, how to interpret emission test readings, and how to perform repairs. Additional instruction will be necessary on how to operate the emissions analyzer and analyzer quality assurance procedures. Because several brands of analyzers will be used in the program, instruction on these procedures can best be provided by the analyzer manufacturer.

Missouri now has a group of licensed inspector/mechanics but that licensing procedure did not include any requirement for instruction or testing relative to emission testing and related adjustments and repairs. To fulfill EPA requirements and to meet program objectives, it is recommended that all inspector/mechanics be required to pass another written test for competancy relative to emissions testing and repair, and pass a practical test on emission analyzer use and quality assurance procedures. Requirements to take the test should be a certificate that the state training course has been completed, and a certificate from the analyzer manufacturer that the applicant is competent to operate the emissions analyzer.

REFERENCES

PEDCo Environmental, Inc. 1981. Support Document for Development of the Missouri Inspection/Maintenance Program--Emission Analyzer Specifications. Kansas City, Missouri.

Nevada Environmental Commission and Department of Motor Vehicles. 1979. State of Nevada Air Quality Regulations for Mobile Equipment. Carson City, Nevada.

STANDARDIZED PROCEDURES FOR EMISSIONS AND TAMPERING INSPECTIONS

CONTENTS

	Page
Figures	iii
Tables	iv
1.0 Introduction	1
1.1 Purpose	1
1.2 Requirements, emissions test procedure	1
1.3 Requirements, tampering inspections	4
References	6
2.0 Emissions Test Procedure	7
2.1 Comparison of alternate short test procedures	7
2.2 Check of idle speed	9
2.3 Dilution check	13
2.4 Tire pressure check	15
2.5 Inspection procedures for vehicles modified to use an alternative fuel	16
2.6 Special problem areas	17
References	19
3.0 Tampering Inspections	20
3.1 Comparison of procedures to inspect for tampering	20
3.2 Recommended procedures for tampering inspections	23
3.3 Time and costs estimates for tampering inspections	26
References	27
Appendix A Sources for Manufacturer's Emissions Control Manuals	29

FIGURES

Number		Page
2-1	Excess Emissions Identified versus Failure Rate for Short Tests	8
2-2	Data from Eight 1970-1976 Model Year Vehicles	12

TABLES

Number		Page
2-1	Vehicle Emission Inspection Modes for Existing I/M Programs	10
3-1	Tampering Inspections in States with Existing I/M Programs	22

SECTION 1.0

INTRODUCTION

1.1 PURPOSE

The purpose of this report is to provide technical information to the State of Missouri on standardized procedures for emissions testing and tampering inspections for a mandatory decentralized inspection/maintenance (I/M) program. This report will serve as the technical basis for the state in adopting regulations relative to the test procedure.

1.2 REQUIREMENTS, EMISSIONS TEST PROCEDURE

1.2.1 U.S. Environmental Protection Agency (EPA) Requirements

Section 207(b) related rules and regulations (U.S. Environmental Protection Agency 1980) contains requirements for the testing procedure in the description of an approved short test. To satisfy Section 207(b) requirements, any of three tests can be used. These tests are as follows:

1. Idle test
    - Engine at normal operating temperature with all accessories off
    - Analyzer warmed up in stabilized operating conditions
    - (Optional) engine may be preconditioned by operating it at 2500 ±300 RPM for up to 30 seconds
    - With engine idling and transmission in neutral, insert probe. Record exhaust concentrations after stabilized readings are obtained or at the end of 30 seconds, whichever occurs first
    - Repeat for multiple tailpipes, numerically average results

2. Two-speed idle test
   - Engine at normal operating temperature with all accessories off
   - Analyzer warmed up in stabilized operating conditions
   - Attach tachometer pick up
   - With engine idling and transmission in neutral, insert probe. Record exhaust concentrations after stabilized readings are obtained or at the end of 30 seconds, whichever occurs first
   - Repeat for multiple tailpipes, numerically average results
   - Increase engine speed to 2500 ±300 RPM, repeat test
   - Allow engine speed to be reduced to free idle, repeat test
   - Final results will be the lowest HC and CO readings from either idle test, and/or from the high speed idle test
   - The test can be terminated after the first idle measurement if measured exhaust concentrations are below the standard
3. Loaded test
   - Engine at normal operating temperature with all accessories off
   - Analyzer warmed up in stabilized operating conditions
   - Place vehicle on dynamometer
   - Insert probe
   - (Optional) High speed mode, maximum 50 mph and 30 second duration for preconditioning
   - Drive for automatic or third gear for manual transmissions shall be used. Operate vehicle at 30 ±1 mph roll speed while measuring exhaust HC and CO. Record concentrations after stabilized readings are obtained or at the end of 30 seconds, whichever occurs first.

- Repeat for multiple tailpipes, numerically average results.
- With engine idling and transmission in neutral, record exhaust concentrations after stabilized readings occur or at the end of 30 seconds, whichever comes first
- Repeat for multiple tailpipes, numerically average results
- Results of either the loaded mode or the idle mode can be used according to the choice of the operating jurisdiction

Section 207(b) requirements do not require any tampering or equipment checks.

In addition to the Section 207(b) requirements, recommendations for the test procedure are contained in an EPA draft report (U.S. Environmental Protection Agency 1981a). These recommendations are:

- Pre-1981 vehicle, idle test with 2500 RPM preconditioning
- 1981 and later vehicle, pass/fail determination at both idle and 2500 RPM
- Randomly sample vehicles for idle speed to determine if motorists are increasing idle speed to lower test results
- Consider a dilution check
- Check tire pressure

The EPA has no specific requirements for the testing procedure in the 1978 EPA policy memorandum (Hawkins 1978). The 1982 SIP review checklist (Gray 1981) requires only that the test procedure be described and that the test procedure include "an exhaust or other test which demonstrates that proper maintenance has been performed".

1.2.2 State of Missouri Requirements

Since there is no emissions test currently required in Missouri, there are no procedures for emission testing.

1.3 REQUIREMENTS, TAMPERING INSPECTIONS

1.3.1 U.S. EPA Requirements

Section 203(a)(3), in part, "prohibits manufacturers, dealers, fleet operators, and commercial service facilities from knowingly removing or rendering inoperative any device or element of design installed on or in a motor vehicle or motor vehicle engine in compliance with regulations following its sale and delivery to the ultimate purchaser" (U.S. EPA 1981b). Prior to vehicle sale, the act need not be done knowingly. Of note is that the law does not apply to tampering done by an individual to his personal car.

A draft Field Office Tampering Manual (U.S. EPA 1981b) has been prepared as a reference document for EPA enforcement personnel who conduct automotive testing inspections. Procedures are included for inspecting eleven systems or devices. These are:

1. Catalytic converter
2. Exhaust gas recirculation (EGR) system
3. Air injector reactor (AIR) system
4. Heated air intake system
5. Idle stop solenoid
6. Idle limiter caps
7. Vacuum spark retard system
8. Positive crankcase ventilation (PCV) system
9. Evaporative emission control system
10. Fuel tank cap
11. Filler tank restrictor

1.3.2 State of Missouri Requirements

The State of Missouri has requirements for an inspection of air pollution control devices (Missouri State Highway Patrol 1980). Existing state requirements apply to 1968 and later model years. Diesel fuel vehicles or vehicles operating exclusively on propane fuel or compressed gas are exempted. Requirements are:

- Check positive crank case ventilation (PCV) system for integrity and vacuum suction

- Check air injection system for integrity and belt slippage

- Check for modifications to the air injector system. Reject vehicle if there are loose wires or if any part of the air pollution control system is missing.

- Check catalytic converter. For vehicles manufactured between 1975 and 1980, if equipped, reject if the catalytic converter is bypassed, modified, or has leakage. For 1981 or later model vehicles, reject if vehicle does not have a converter and apply criteria for 1975 to 1980 models.

REFERENCES

Gray, C. L. 1981. Inspection/Maintenance Program 1982 SIP Processing. Ann Arbor, Michigan.

Hawkins, D. C. 1978. Memorandum to Environmental Protection Agency Regional Administrators. Washington, D.C.

Missouri State Highway Patrol. 1980. Missouri Motor Vehicle Inspection Regulations. Jefferson City, Missouri.

U.S. Environmental Protection Agency. 1980. Motor Vehicles; Emission Control System Performance Warranty Short Tests. 40 CFR Part 85.

U.S. Environmental Protection Agency. 1981a. EPA Recommendations Concerning Emission Inspection Procedures for Motor Vehicle Inspection and Maintenance Programs--Draft. Ann Arbor, Michigan.

U.S. Environmental Protection Agency. 1981b. Field Office Tampering Inspection Manual--Draft. Washington, D.C.

SECTION 2.0

EMISSIONS TEST PROCEDURE

2.1 COMPARISON OF ALTERNATE SHORT TEST PROCEDURES

2.1.1 Overview

The idle test is the simplest of all 207(b) approved I/M emission short tests. A preconditioning mode (2500 RPM) is optional. The two-speed idle test includes emissions testing during three distinct sampling modes; idle, 2500 RPM, and idle. Emissions from any mode can be evaluated against the standard. The loaded test requires emission measurement at 30 mph cruise speed on a dynamometer and at idle. Emissions from either mode can be evaluated against the standard. EPA has evaluated the effectiveness of each type of test relative to its ability to identify excess emissions.

Preconditioning the engine at ±2500 RPM before the idle test is an option with the idle test procedure. The purpose of the preconditioning is to reduce test variability by cleaning out an engine that has been idling for an extensive period. While engineering judgment indicates preconditioning may be desirable, data to prove its effectiveness are not available (U.S. EPA 1981).

A comparison of the two-speed idle test with compliance based only on the idle mode, and a loaded test is shown in Figure 2-1. The two tests are compared to the Federal Test Procedure (FTP) which is the benchmark. The data are for pre-1981 vehicles. For practical purposes, the short tests are about equal in their ability to identify high emitting pre-1981 vehicles (U.S. EPA 1981).

For 1981 and later vehicles, EPA compared the effectiveness of the two-speed idle test, with compliance required at idle and 2500 RPM, with the loaded test. Again, the two techniques were comparable. However, the idle test was only about 71 percent as effective as the other two test procedures.

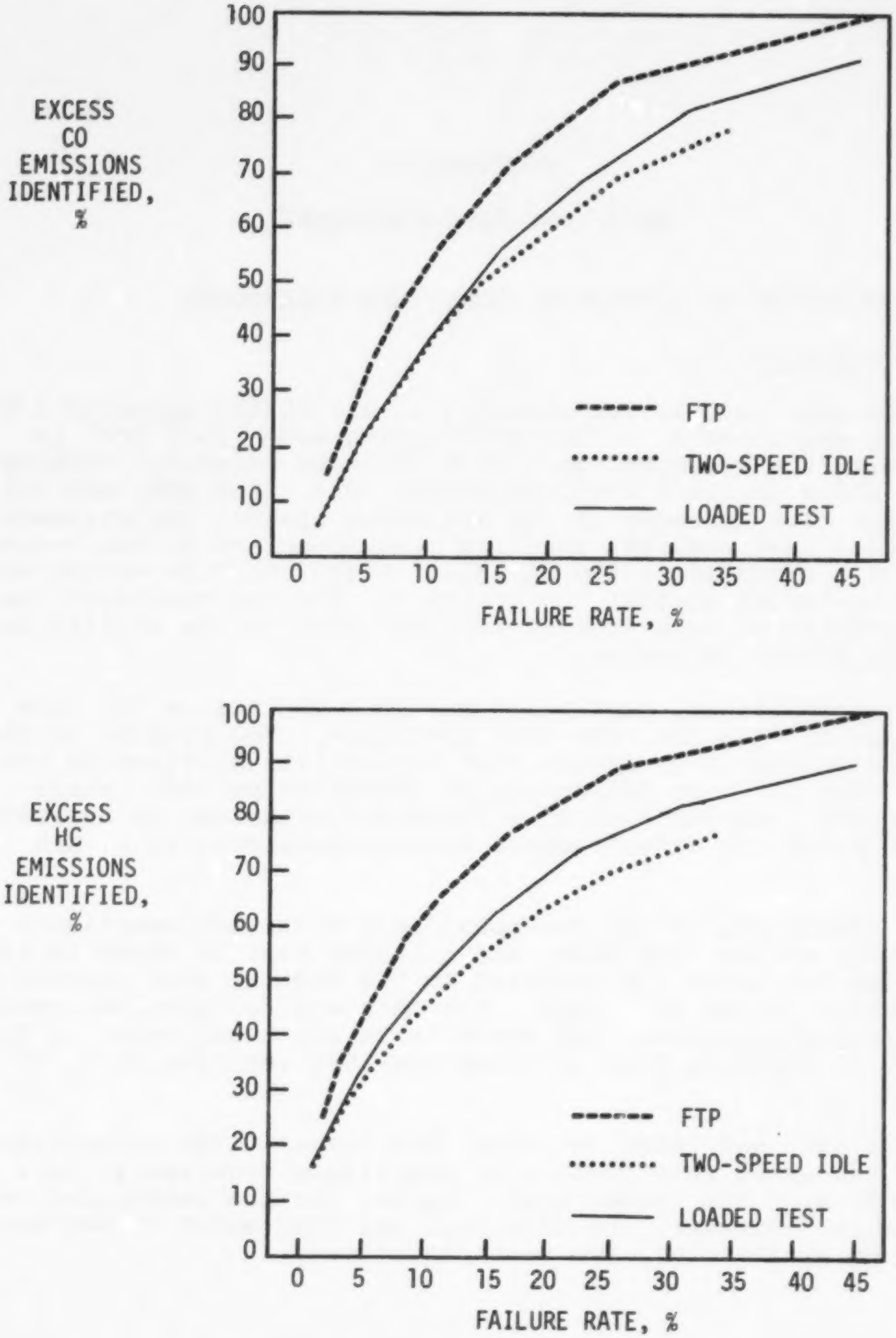


Figure 2-1. Excess emissions identified versus failure rate for short tests.

2.1.2 Evaluation

A loaded test can be eliminated from consideration as impractical in a decentralized program. Significant capital expenditures would be required at over 1000 stations. In addition, the area with the dynamometer must be dedicated to emissions testing, thereby eliminating much of the vehicle repair area at many facilities.

The decision to be made is between an idle test and a two-speed idle test. Related decisions are whether to allow preconditioning and whether to have a different test for pre-1981 and 1981 and later vehicles.

Personnel from all existing I/M programs (Arizona, California, New Jersey, New York, Nevada, Ohio, Oregon, and Rhode Island) were contacted to determine why they picked a specific type of test (idle, two-speed idle, loaded, or other). These data are shown in Table 2-1. Specifically, any other test data, other than the EPA data referenced in Subsection 2.1.1, was sought. No other test data was available. Existing programs picked their test method on the basis of cost to implement, time to perform the test, what the emission analyzer manufacturer recommended, and political expediency. Based on this survey of existing programs, it is concluded that the EPA data relative to the effectiveness of alternate testing procedures is the best available.

Based on the EPA data, it is recommended that the idle test with preconditioning be used for pre-1981 vehicles and that the two-speed idle test with compliance required at idle and 2500 RPM be used for 1981 and later vehicles.

If it is not politically expedient to adopt different test procedures for different year vehicles, it is recommended that the two-speed idle test with compliance required at both levels be used. This alternate recommendation is based on the EPA finding that the idle test is only about 71 percent as effective as the two-speed idle test for 1981 and later vehicles. Adoption of the idle test for the newer vehicles would significantly impact effective program stringency at an increasing rate throughout the program.

2.2 CHECK OF IDLE SPEED

2.2.1 Overview

It is possible for vehicles that would normally fail an idle test to pass the test by simply raising the idle speed of the engine. An unusually high idle speed lowers the idle emission

TABLE 2-1. VEHICLE EMISSION INSPECTION MODES FOR EXISTING I/M PROGRAMS

	State implementation							
Inspection mode	New York	New Jersey	Ohio	Oregon	Arizona	Nevada	Rhode Island	California
Idle HC and CO	Pass/fail	Pass/fail	Pass/fail[a]	Pass/fail	Pass/fail	Pass/fail	Pass/fail	Pass/fail
2500 RPM HC and CO				Condition veh/data collection	Condition veh/data collection	Condition veh/data collection 2250 RPM		Condition veh/data collection
Loaded HC and CO								Data collection
Exhaust dilution CO_2	Pass/fail 4%			Pass/fail 3%	Pass/fail 4.5%			Pass/fail 4.5%
Idle speed	Pass/fail			Pass/fail		Check and adjust		Pass/fail

[a] Transmission in drive - automatic transmission.
Transmission in neutral - manual transmission.

concentration. Figure 2-2 shows this effect on eight cars tested by EPA. The higher idle speed does not significantly reduce overall FTP emissions of the vehicle measured in grams/mile. Therefore, a vehicle with an increased idle speed over the manufacturers specifications has a better chance to pass the design emission limits while being dirtier than some other vehicles which fail the idle test. This has the effect of reducing program effectiveness.

Vehicles are set at a high idle speed for a variety of reasons. These reasons include simple tune-up errors, a preference for a faster and smoother idle and a quick-fix for a stalling vehicle with another malfunction. Conceivably, the idle could also be increased to pass the emissions test.

EPA suggests that if an idle speed inspection is instituted, 1200 RPM should be the lowest cutpoint used for the inspection. Below this value, too many clean cars would fail the idle speed check. Four cylinder engines tend to have high idle speeds more frequently than six and eight cylinder engines. Therefore, EPA recommends separate cutpoints to obtain equal idle speed failure rates in each category. The recommended cutpoints are 1500 RPM for four-cylinder engines and 1200 RPM for six- and eight-cylinder engines. The idle speed check should only be used as a criterion for a valid emission test. If a car has a high idle speed and passing idle HC and CO levels the test should be considered invalid. The idle speed should be corrected and the vehicle retested to determine the emission levels.

For the opposite case, high idle speed and failing idle HC and CO levels, the test should be considered valid, since lowering the idle speed would not correct the cause of the high emission levels.

As an option to checking the idle speed of all vehicles, EPA suggests initial collection of idle speed data for all vehicles during early phases of the program to determine if high idle speeds are a problem. If they are not, the idle speed check can be eliminated.

2.2.2 Evaluation

In Subsection 2.1, an idle test with preconditioning for pre-1981 vehicles and a two-speed idle test for later vehicles was recommended. Both test procedures require the use of a tachometer (for preconditioning or the 2500 RPM speed). Therefore, it would be very easy to implement the idle speed check. It is recommended that a regulation for idle speeds checks be adopted.

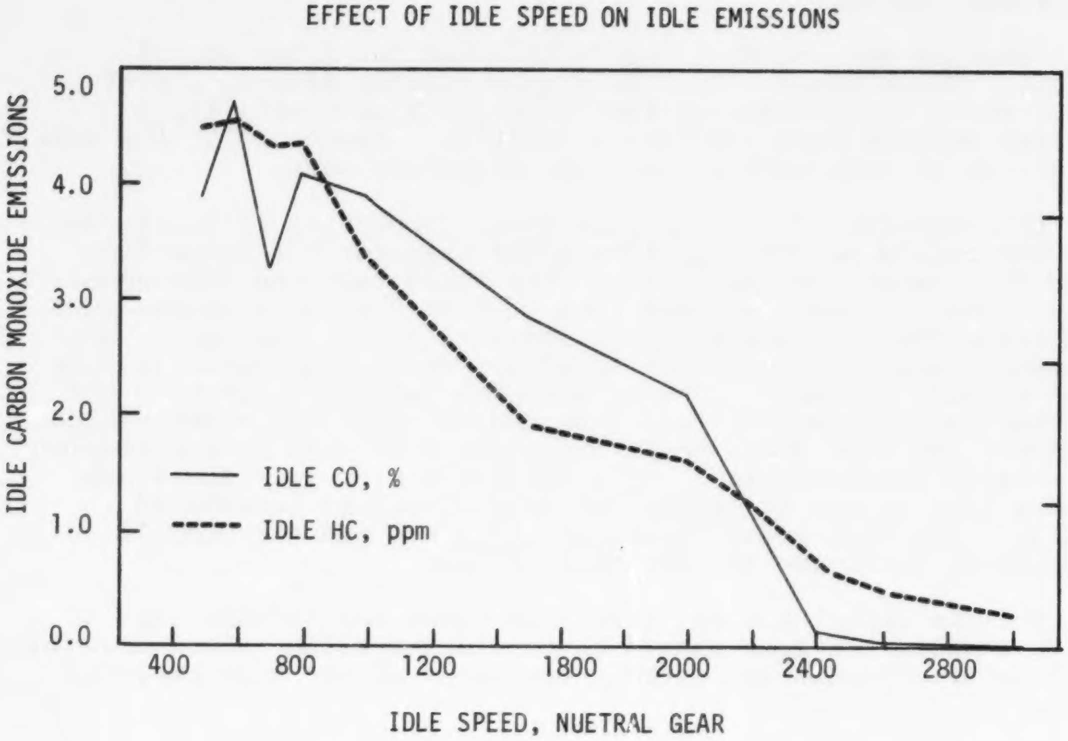


Figure 2-2. Data from eight 1970-1976 model year vehicles

The regulation should include the cutpoints recommended by EPA: 1500 RPM for four-cylinder engines and 1200 RPM for six-and eight-cylinder engines. Any test of a vehicle with a high idle speed and passing emission levels should be considered invalid. The vehicle should be repaired and retested before a determination of its emission levels is made.

Since a tachometer is necessary for determining engine speed, several questions may arise pertaining to the accuracy and reliability of these devices. According to one instrument manufacturer, few problems are experienced with tachometers, and these generally occur after the fifth or sixth year of use (D. Miller 1981).

Service personnel for this manufacturer carry a calibration standard and check the calibration of the units during each service call. These checks have shown that the units are usually within 1 to 2 percent of the standard. From the conversation it appears that only minimal problems can be expected with the use of the tachometer. However, the state may want to be assured that the tachometers used are in calibration. Therefore, the state inspectors could be provided with a calibration standard and the tachometer used for emissions testing audited during each monthly audit. These 110 volt, 60 cycle standards could be purchased for less than $100 apiece.

There are two basic types of tachometers that would be used for evaluating engine speed. The simplest type attaches to a spark plug wire with a spring-loaded clip. The other requires that the tachometer be wired in series between a spark plug and the distributor. Attaching the first type would require little more time than opening the hood of the vehicle. The second type would probably require no more than a minute of additional time for a trained mechanic.

2.3 DILUTION CHECK

2.3.1 Overview

Dilution of engine exhaust before it reaches the working part of the emission analyzer will cause emission readings to be lower than the true values. Dilution can occur either from a leaking vehicle exhaust system, inadequate sampling of the exhaust (probe not fully inserted into tailpipe) or a leaking analyzer sampling system. Of the three causes, the first cause is of primary concern here. Design specifications for long probe lengths minimize the second cause. Analyzer leak checks minimize the third cause. In any event, outside air mixed with the exhaust cause lower measured values allowing some vehicles to falsely pass the emissions test. Dilution can be checked by using an analyzer with CO_2 measurement capability or less accurately, by visual inspection. In existing programs with CO_2 measurement capability, 1 to 3 percent of all vehicles are failed for dilution.

EPA makes no recommendation concerning dilution checks for decentralized programs.

2.3.2 Evaluation

As noted above, there are two ways to check for dilution caused by a leaking vehicle exhaust system, i.e., CO_2 measurement and visual inspection.

CO_2 measurement capability on a new analyzer costs approximately $600. Retrofit of the capability to a CO/HC analyzer is not usually practical. A separate CO_2 measurement instrument costs approximately $1500 (U.S. EPA 1981). Since some decentralized testing stations already have an adequate CO/HC analyzer without the CO_2 capability, the cost of adding CO_2 measurement capability to the program would range from $600 to $1500 per station for 1000 stations.

The less effective visual check would be free of capital cost but would require a minute or two of labor time. There is no data to indicate how less effective the visual test is. Since only 1 to 3 percent of all vehicles are failed due to dilution, with a CO_2 analyzer, (U.S. EPA 1981) if the visual check identified half of the dilution occurrences, only 0.5 to 1.5 percent would pass when they should fail due to dilution.

In quantitatively evaluating the benefit of CO_2 measurement capability, the following assumptions were made:

- 1000 test locations, of which 800 are buying new analyzers and 200 must purchase a separate CO_2 measurement instrument
- A 1980 specification HC/CO analyzer cost of $5500 and a HC/CO/$CO_2$ analyzer cost of $6100 amortized over five years

With these assumptions, CO_2 measurement capital cost for the entire program would be $780,000, or $780 per station. Added to the cost would be the direct expense and labor cost for measurement and quality assurance.

No method could be derived for accurately comparing costs and benefits from adding CO_2 measurement capability to the program. However, assuming that 0.75 percent more vehicles would be failed with CO_2 measurement capability than would be failed with a visual dilution check, about 1800 more vehicles would fail per year. Assuming the failures were equally distributed among the 1000 stations, and amortizing the average $780 capital cost over 5 years, the cost for an additional 1.8 failures per station per year would be about $156 per station per failure per year. This would seem to be excessive. It is recommended that a visual check be made of exhaust system integrity to identify dilution.

2.4 TIRE PRESSURE CHECK

2.4.1 Overview

The lower the pressure in a car tire, the more the tire bends as it rolls. The bending causes increased fuel consumption. Underinflation by 5 pounds causes a 2 percent decrease in fuel economy (U.S. EPA 1981).

While the primary purpose of an I/M program is to reduce air emissions, a secondary purpose is increased fuel economy. A tire pressure check would contribute to the second purpose. EPA recommends that tire pressure checks be required or encouraged and that an on-premise air hose be required for tire inflation (U.S. EPA 1981). It is recommended that the tire pressure be determined and inflated at ambient conditions (when the tire temperature is not increased due to travel). The pressure should be set at a level about three pounds per square inch (PSI) above the recommended comfort driving pressure (generally 26 to 28 PSI). It is recommended that the tires not be inflated above the maximum inflation pressure shown on the sidewall of the tire (generally 32 PSI).

Missouri's existing safety inspection program requires a visual tire check for wear but not for inflation level.

2.4.2 Evaluation

EPA reports (U.S. EPA 1981) that 63 percent of all tires are underinflated by an average of 4.5 pounds per square inch below the recommended comfort pressure. Therefore, on a fleet basis, fuel economy would be increased by 1.1 percent if the tires were inflated to the recommended comfort pressure. The fuel economy benefit can be increased beyond the 1.1 percent value. If all tires at less than 28 PSI are inflated to exactly 28 PSI, the fuel savings increases to 1.5 percent. If 32 PSI is used, the savings is almost 3 percent.

The tire pressure check could be easily added to the inspection procedure. Checking the pressure in four tires would require a maximum of three minutes labor. Assuming a burdened mechanic labor cost of $20.00 per hour, that all testing locations have a compressor, and that 1.2 million vehicles will be tested each year, the cost of the tire pressure checks would be $1.00 per car or $1.2 million annually.

EPA estimates that tire underinflation of 5 pounds cost a motorist about $13 per year in added fuel cost. Using the conservative parameters noted above (63 percent underinflated by 4.5 pounds), average savings per vehicle would be $7.37 or $8.8 million for a 1.2 million vehicle population.

Even allowing for the conservative cost saving assumptions, the cost saving is obvious. However, the tire pressure check will increase the inspection cost to the station operator (probably without an increase in inspection fee) and is outside of the legal intent of an I/M program. Therefore, the decision to check tire pressure is arguable.

The purpose of I/M is to reduce emissions by keeping in-use vehicles properly tuned. A properly tuned vehicle has both lower emissions and improved fuel economy. Maintaining correctly inflated tires also improves fuel economy and overall vehicle emissions should also be reduced, since smaller quantities of fuel are burned. This is an area where inspections could be construed to include fuel economy considerations along with emissions and safety.

It was conservatively assumed that $8.8 million could be saved by the motorists in the I/M program if the tire pressure checks were implemented. The cost to the station operator would be about $1 per vehicle or $1.2 million annually for the program. These figures imply an overall savings of about $7.6 million which is probably near the total cost of the I/M program. Given these estimated cost figures, the tire pressure check should be seriously considered for inclusion in the program.

2.5 INSPECTION PROCEDURES FOR VEHICLES MODIFIED TO USE AN ALTERNATIVE FUEL

2.5.1 Overview

Gasoline-powered vehicles may be converted to use a fuel other than gasoline. The fuels normally used are liquefied petroleum gas (LPG) and either compressed (CNG) or liquid natural gas (LNG). Some vehicles are converted so that gasoline can be used at times and the alternate fuel at other times (dual fuel system). Complete fuel conversion systems exclusively use the alternate fuel.

There are several options available for emission inspection of these modified vehicles. The existing Missouri safety inspection regulations specifically exempt vehicles operating exclusively on propane or compressed gas from inspection of emission control devices. This exemption could be expanded to include those vehicles with dual fuel systems.

A second option would be to retain the exemption for complete fuel conversions and test the dual-fuel systems for gasoline.

The third option would be to test the vehicles at their regular emission standards regardless of the fuel used. Those vehicles with dual-fuel systems would be tested for both fuels.

2.5.2 Evaluation

EPA makes no specific recommendation for testing modified vehicles. Rather they recommend that gasoline-powered vehicles be included in an I/M program. Only California specifically exempts dual-fuel and permanently converted vehicles from the inspection. Other states refer only to gasoline-powered vehicles. It is generally assumed that excess CO and HC emissions are not a problem for vehicles using an alternate fuel, since these fuels burn cleaner than gasoline.

The proposed I/M program for Missouri refers to both gasoline and dual-fuel system vehicles since complete conversion vehicles are presently exempted under the safety inspection regulations. Consequently, it is recommended that dual fuel systems be included in the I/M program. However, these vehicles need only be tested for gasoline. The test procedures for these vehicles will be identical to those for vehicles that are not modified.

2.6 SPECIAL PROBLEM AREAS

2.6.1 Overview

The only special problem that has not been considered is the testing procedure for Ford motor vehicles equipped with an air-pump diverter valve. While these vehicles are idling, this valve causes air from the air pump to be vented to the atmosphere rather than to the exhaust manifold and through the calatylic converter. The primary reason for diverting the air is to prevent the catalytic converter from overheating.

The implication of this valve for the idle emission test is that the resulting emission value will be artificially high unless certain precautions are taken. The first is that the inspector be aware of the problem. The second precaution is to precondition the vehicle at 2500 RPM with the probe in the tailpipe for 30 seconds. Then, the engine should be allowed to reach curb idle and the emission levels should be read within 30 seconds.

2.6.2 Evaluation

The inspection procedures recommended in Subsection 2.1.2 should be sufficient to address this problem either preconditioning the engine at 2500 RPM or the two stage idle test will take care of the problem. The only specific requirement needed for the idle test is that all vehicles, not just Fords, be accelerated for 30 seconds at 2500 RPM with the probe in the tailpipe and the emission levels read within 30 seconds of the vehicle reaching curb idle.

REFERENCES

U.S. Environmental Protection Agency. 1981. EPA Recommendations Concerning Emission Inspection Procedures for Motor Vehicle Inspection and Maintenance Programs--Draft. Ann Arbor, Michigan.

Miller D. 1981. Conversation with Regional Sales Manager, Sun Electric Corporation, Olathe, Kansas.

SECTION 3.0

TAMPERING INSPECTIONS

3.1 COMPARISON OF PROCEDURES TO INSPECT FOR TAMPERING

3.1.1 Overview

Tampering, as referred to in this section, is the removal, disconnection, or making inoperative, any device that is an operational part of the air pollution control system of a motor vehicle as required by state or federal law. Eleven devices or systems are on most recent model cars except in California where retrofit devices have increased the number. The 11 devices or systems are:

1. Catalytic converter
2. Exhaust gas recirculation (EGR) system
3. Air injection reaction (AIR) system
4. Heated air intake system
5. Idle stop solenoid
6. Idle limiter caps
7. Vacuum spark retard system
8. Positive crankcase ventilation (PCV) system
9. Evaporative emission control system
10. Fuel tank cap
11. Filler tank restrictor

The basic problem with tampering inspections is the difficulty in performing one. Each car model has different emission control devices and systems. In a few instances, systems have changed in the same model year on the same model. With such variation, the tampering inspector must know: (1) what systems each model was manufactured with; and (2) how to recognize the system. The first problem requires a set of several manuals. No single manual is available that lists all required equipment on each model. The second problem requires mechanic training.

State programs have reacted to tampering inspections in different ways. In California, which is a centralized program and where there are retrofit devices besides the basic systems, the inspector enters the make and model of car to a computer terminal which in turn lists the required devices. This takes care of the first problem listed in the previous paragraph but not the second. In Nevada, a tampering inspection is required. However, the requirement is not being enforced because mechanics did not have the requisite skills to perform the inspections. States not having a tampering inspection requirement generally do not because of the difficulty in performing the inspections. Table 3-1 lists the vehicle components inspected for tampering by the three states that require the inspection for their existing I/M program.

Missouri's existing safety inspection program regulations require an inspection of the catalytic converter, the PCV system, and the air injection system.

3.1.2 Evaluation

Missouri's experience in implementing its regulations requiring inspection of the catalytic converter, PCV system, and air injection system has been similar to other states efforts to require tampering inspections. While some inspection failures have been caused by tampering, enforcement has been difficult because of at least two factors. First, no single manual is available that lists all required equipment for every model car. Therefore, garage station personnel do not know what devices were manufactured on the car. The second problem appears to be one of attitude. Since the primary thrust of the existing program is safety, garage station personnel place less emphasis on inspection for air pollution related equipment. About 1 percent of all vehicles are failed for air pollution equipment (Missouri State Highway Patrol 1981).

EPA, at the national level, acknowledges the difficulty in completing a tampering inspection for all 11 items (U.S. Environmental Protection Agency 1981). Personnel have unofficially suggested a check that includes at least the following items: catalytic converter, EGR system, missing belt from air pump, heated air intake system, and filler neck restrictor.

It is recommended that the Missouri I/M program include tampering inspections for the following devices or systems:

TABLE 3-1. TAMPERING INSPECTIONS IN STATES WITH EXISTING I/M PROGRAMS

Vehicle component	Components inspected		
	Oregon	Nevada	California
Catalytic converter	V[a]	V	
EGR valve	V	V	F[b]
Air injection system	V	V	V
PCV valve	V	V	V
Thermostatic air cleaner	V	V	V
Fuel fillerneck	V		
Exhaust system modifications	V		V
Engine modifications	V		V

[a] V = visual check.

[b] F = functional check.

- Catalytic converter
- EGR system
- Air injection reaction system
- Heated air intake system
- PCV system
- Fuel tank cap
- Filler neck restrictor

Selection of the items to be examined was based on ease of checking the device or system, practicality of checking the device or system, and time required to check the device or system. The check for the catalytic converter will require the use of a lift or jack to check underneath the vehicle. However, it is already necessary to hoist the vehicle as part of the safety inspection to check ball joints, suspension linkage and wheel play. The EGR, air injection, heated air intake, and PCV systems can be visually checked by lifting the hood. No removal of the air cleaner or other equipment would be required. The fuel tank cap and filler neck restrictor can be easily visually checked.

Inspection of the idle stop solenoid and the idle limiter caps was rejected because of the need to remove the air cleaner and because of the difficulty of determining what equipment belongs on different models. Inspection of the vacuum spark retard system was rejected for similar reasons. Inspection of the evaporative control system was rejected because of model variations and the need to make a complete underbody check not possible with a car on a jack.

3.2 RECOMMENDED PROCEDURES FOR TAMPERING INSPECTIONS

3.2.1 Catalytic Converter

Inspection Procedure:

1. Check for the presence of the catalytic converter. A missing catalytic converter is tampering. If there is any uncertainty as to whether a vehicle should have a catalytic converter, the underhood vehicle emission control information label should be checked. On most vehicles, the emission control systems are listed on this label.

2. On General Motors and American Motor models check the plug in the body of the canister. Both companies now use a pressed-in plug in most post-1976 models. If the plug is nonstandard or is damaged, the catalyst material may have been drained. The plug cannot be removed readily and would probably be damaged if removed. Removal of the catalyst material is tampering.

3.2.2 EGR System

Inspection Procedure:

Inspect the system to determine if the valve, sensor(s) and hoses are in place. All EGR disconnections and misroutings are considered tampering. Note that this would include smashed valves, holes in valves, and vacuum hoses plugged with bolts, fuses, or BB's. All vacuum hoses in the system should be physically checked at connection points by squeezing to determine if they have been physically obstructed.

The EGR system is an important control system for reducing nitrogen oxides (NO_x). NO_x cannot be detected by existing emission analyzers. The checks listed above will ensure that the system is intact and that the lines running through the system are not plugged. The procedure to determine if the system has been rendered inoperable would be costly. Consequently, the emission control benefit of inspecting this system may not be fully realized by only a visual check.

3.2.3 Air Injection Reaction System

Inspection Procedure:

If the system is an air pump system, check for the presence of the pump and the belt. Inspect all hoses for obstructions by squeezing near connection parts.

If the system is not an air pump system, no inspection for this system is required.

3.2.4 Heated Air Intake System

Inspection Procedure:

1. Check the vacuum line from the carburetor to the thermal vacuum valve and from the thermal vacuum valve to the vacuum motor on the air cleaner horn. If either line is missing, plugged, or disconnected it is considered tampering. It normally requires a deliberate act by a mechanic or owner to disconnect these lines.
2. Check for the presence of the "stove pipe" which is the black paper/foil or metal connection between the exhaust manifold shroud and the air cleaner horn. If it is present but not properly connected, or if it is torn or deteriorated, it is considered disconnected.
3. Check the air cleaner top. If it is inverted, raised due to nonstock air filter, or holes are punched in the

air cleaner, the heated air intake is considered disconnected. This is considered tampering because the heated air intake is deliberately defeated and because it may render the PCV system, some evaporative control systems, and other thermal vacuum valves inoperative.

3.2.5 PCV System

Inspection Procedure:

Check the PCV line for proper routing and connections. Verify that the PCV valve is present and that there is no relief device in the hose from the crankcase to the air filter. If there is such a device or if either the line between the PCV valve and carburetor or the "fresh air tube" from the air cleaner to the crankcase are disconnected, it is considered tampering.

3.2.6 Fuel Tank Cap

Inspection Procedure:

1. Check for the presence of the cap. If it is missing, it is considered cause for failure of the vehicle.
2. Check the condition of the cap. If there are holes in the cap, it is considered tampering. If the gasket does not seal properly, it is considered malfunctioning. Either condition is cause for failure.

3.2.7 Filler Neck Restrictor

Inspection Procedure:

Check the filler neck inlet for the presence of a restrictor if the car requires unleaded fuel. Also check that the decal label for "unleaded fuel only" is still applied near the gasoline inlet. If there are any doubts as to whether a vehicle requires unleaded fuel, check the dashboard for an "unleaded fuel only" label near the fuel gauge.

The state could greatly assist garage station personnel in performing tampering inspections by compiling a list of devices or systems required on each vehicle model. This information is available (Appendix A and other sources) but is contained in several manuals that most service stations could not be expected to have. Compilation of these resources by the state, with periodic updates, would significantly improve the quality of tampering inspections.

3.3 TIME AND COSTS ESTIMATES FOR TAMPERING INSPECTIONS

In the previous subsections seven items were recommended for inspection for tampering. It is difficult to estimate the amount of time needed to check each item, especially since these items would be only a small part of the entire inspection process. If the tampering inspection were to be done completely independent of all other parts of the inspection, the time to perform the tampering inspection of the seven items would probably be on the order of 7 to 10 minutes. However, if the tampering inspection was integrated into the overall inspection process, the additional time required to do the inspection would probably be less than five minutes.

If it is assumed that it would take a trained mechanic 5 to 10 minutes to inspect the seven devices, and that his salary is $20 per hour, then the additional cost for the tampering inspection would be $1.67 to $2.33 per vehicle. The annual cost for the entire 1.2 million vehicles would be $2.0 to $2.8 million.

REFERENCES

Colorado State University. 1980. Students Guide for the Federal Course on Tampering Detection. Ft. Collins, Colorado.

Missouri State Highway Patrol. 1981. Telephone conversation with Sargeant L. Walker. Jefferson City, Missouri.

U.S. Environmental Protection Agency. 1981a. Field Office Tampering Inspection Manual--Draft. Washington, D.C.

U.S. Environmental Protection Agency. 1981b. Telephone conversation with S. Albrinck. Washington, D.C.

APPENDIX A

SOURCES FOR MANUFACTURER'S EMISSIONS CONTROL MANUALS

Availability and cost of manufacturers emissions control manuals can be obtained by written request to the following addresses. Check with local dealers for vehicles not listed. They can provide the addresses for obtaining manuals.

1. American Motors Corporation
   Write to: American Motors Corporation
   14250 Plymouth Road
   Detroit, Michigan 48232

2. Chrysler Corporation
   Write to: Chrysler Corporation
   Service Department
   Post Office Box 40
   Detroit, Michigan

3. Datsun
   Write to: Parker Industries, Inc.
   609 Deep Valley Drive
   Rolling Hill Estates, California 90274

4. Ford Motor Company
   Write to: Helm Incorporated
   Post Office Box 07150
   Detroit, Michigan 48207

5. General Motors Corporation
   Write to: GMC Truck & Coach
   Division Printing, Inc.
   Department GMC
   1179 Sylvertis Road
   Pontiac, Michigan 48054

6. Honda
   Write to: American Honda Motor Company Inc.
   Automobile Customer Service Department
   100 West Alondra Boulevard
   Gardena, California 90247 (213)327-8280

7. Toyota
   Write to: Toyota Motor Sales USA, Inc.
   2055 West 190th Street
   Torrance, California 90504
   Customer Relations (312)532-5010

8. Volkswagen
   Write to: Robert Bently Incorporated
   872 Massachusetts Avenue
   Cambridge, Massachusetts 02139